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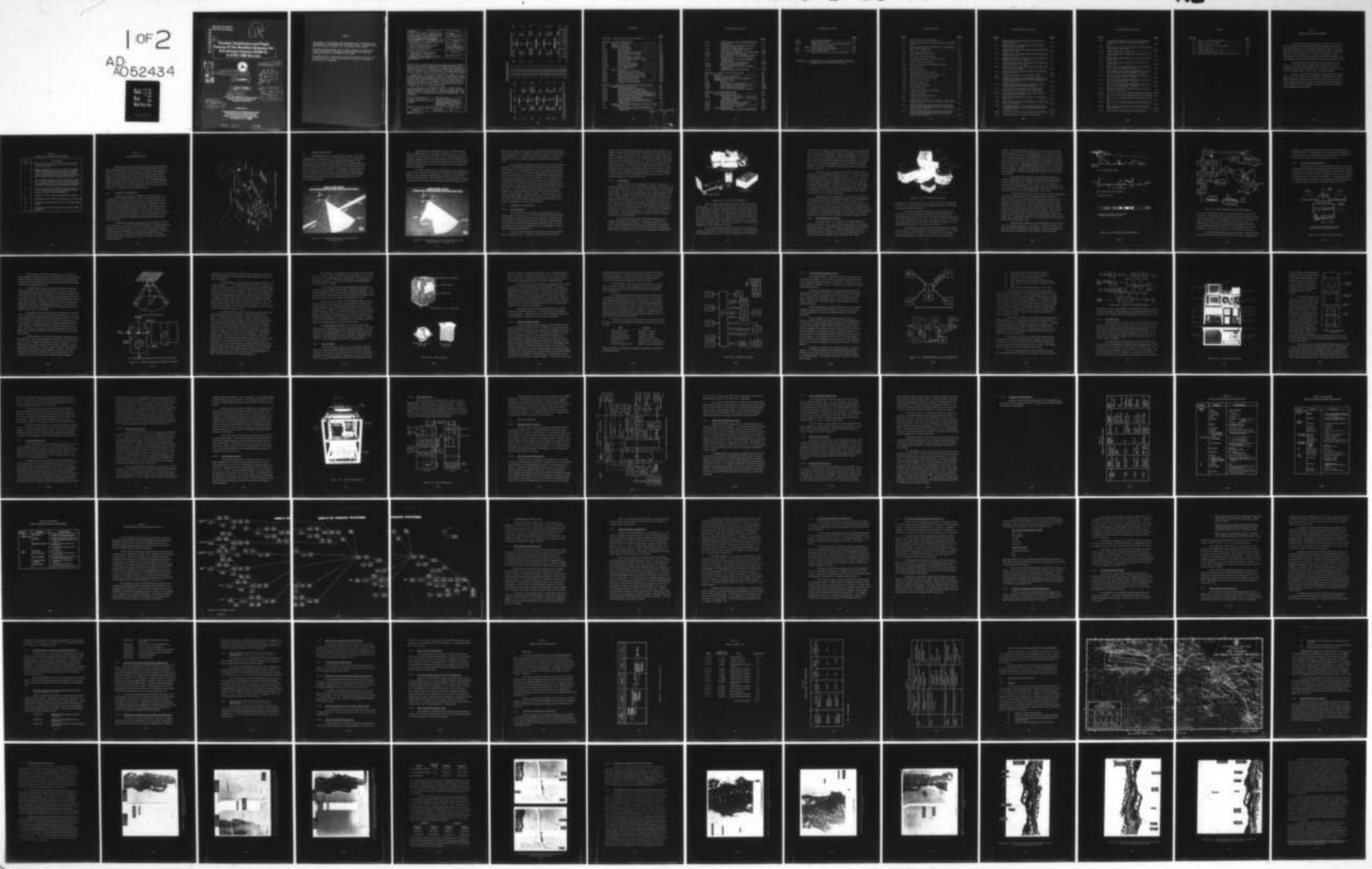

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Transfer, Installation and Flight Testing Of The Modified Airborne Oil Surveillance System (AOSS II) In A HC-130B Aircraft.

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16. Abstract The prototype airborne oil surveillance system (AOSS I) developed for the U.S. Coast Guard by Aerojet ElectroSystems under Contract DOT-CG-22170A was modified and transferred from a HU-16 aircraft to a HC-130B aircraft. The added capabilities of the new system configuration were verified by a flight test program.

Modifications to the system included (1) the addition of a high resolution aerial reconnaissance camera, (2) the addition of a dual look (left and right) capability for the SLAR, (3) automatic SLAR target position location, (4) an airborne remote temperature measurement capability, (5) simultaneous multispectral recording capability for the IR-UV line scanner data, and (6) improved processing of passive microwave imager data.

The proven system capabilities of AOSS I combined with the added capabilities incorporated into AOSS II provide a unique and valuable system to support all U.S. Coast Guard missions. The system is currently operational and based at Elizabeth City, North Carolina.

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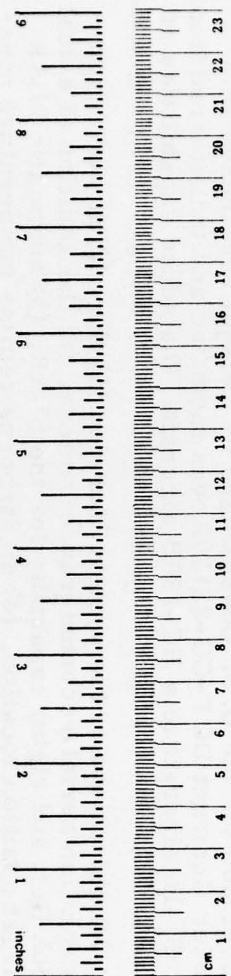
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

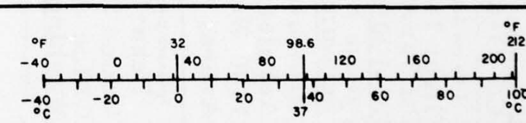
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Section 1

INTRODUCTION AND SUMMARY

This document provides details of improvements to the U.S. Coast Guard Airborne Oil Surveillance System (AOSS), installation of the system aboard U.S. Coast Guard HC-130B aircraft No. 1347 and subsequent flight evaluation of the improved AOSS equipment (AOSS II). This work was accomplished by Aerojet ElectroSystems Company (AESC) under U.S. Coast Guard Contract No. DOT-CG-52660A. Work summarized herein was performed between March 1976 and July 1977.

Modifications to the AOSS equipment are summarized in Table 1-1. The HC-130B installation was configured to preserve multimission utility of the aircraft with minimal effect on the aircraft center of gravity, flight characteristics, and cargo payload.

Section 2 describes the AOSS II hardware and Section 3 gives details of the improvements and installation. Section 4 summarizes flight testing and verification of the system improvements. Section 5 recommends several improvements to increase operational effectiveness of AOSS II based on the flight evaluation and subsequent operational deployment of the system.

Table 1-1

SUMMARY OF AOSS MODIFICATIONS

Task	Description
Ia	PMI image smoothing improvements and increase sensor scan speed
Ib	SLAR modifications for (1) use of both the existing AOSS vertically-polarized antenna and a standard 16-foot horizontally-polarized antenna, (2) video display modifications to accommodate both antennae, and (3) automated SLAR target location readout.
Ic	Line scanner modifications for (1) improved calibration, (2) direct readout of water temperatures and (3) an additional film recorder to permit simultaneous recording of both infrared and ultraviolet channels.
Id	LTN-51 modification to interface with HC-130B autopilot, search mode select unit and flight director, and to permit fleet interchangeability
Ie	Addition of a KS-72 aerial reconnaissance camera
If	Installation of the PMI and line scanner into wing pods
Ig	Integration of AOSS electronics onto a standard cargo pallet
Ih	Integration and bench testing of the improved AOSS equipment

Section 2

AOSS II DESCRIPTION

AOSS II consists of the following major elements: Sidelooking Airborne Radar (SLAR), Passive Microwave Imager (PMI), Line Scanner (L.S.), KS-72 Camera, Data Processor Console, SLAR Equipment Rack, Power Supply Rack, and a LTN-51 Inertial Navigation System. Figure 2-1 shows the general locations of the equipment presently installed onboard the USCG HC-130B aircraft. The following paragraphs explain the purpose of the equipment and describe the AOSS II mission. An overview of each major system element and how it operates is given, followed by a summary of the key system features.

2.1 PURPOSE OF EQUIPMENT

AOSS II is used to detect, identify, and map oil spills. To accomplish this, AOSS II (1) detects ships which may discharge oil in prohibited zones, (2) examines the area in the vicinity of the ship for oily discharges, (3) maps the detected oil slick to establish its location and size, and (4) identifies the violator involved. The purpose of this procedure is to obtain documentation in the form of film and tape recordings, that will enable assessment of civil penalties against oil spill violators. The information obtained as to the location and size of the spill will also expedite the dispatching of the required cleanup equipment to the site.

AOSS II also identifies and maps large spills that result from ship collisions or accidents at offshore drilling sites. In these instances, the source and location of the oil are known, and the AOSS II function provides real-time mapping to track the extent, distribution, and movement of the oil mass. AOSS II also supports the USCG missions of Search-and-Rescue, Enforcement of Laws and Treaties, and International Ice Patrol.

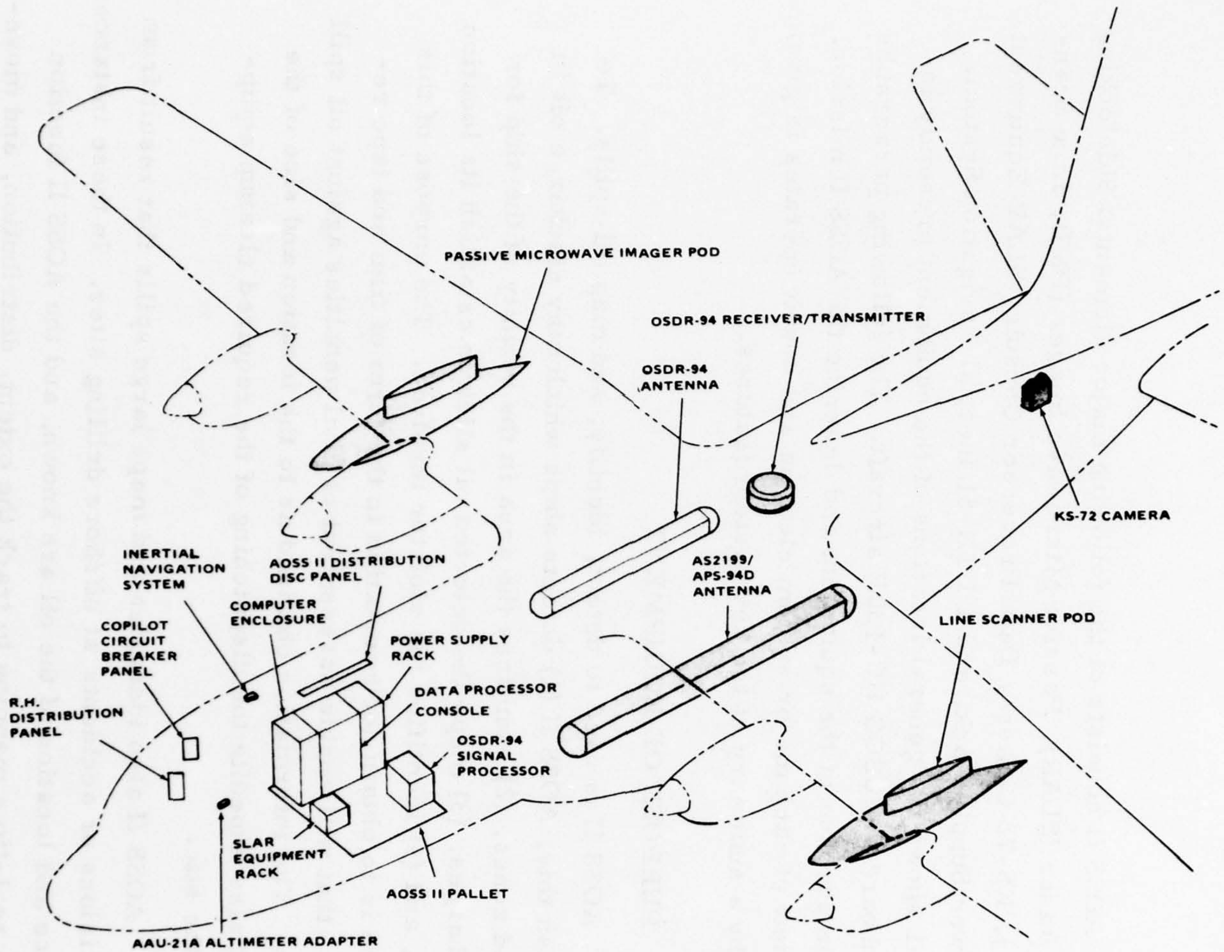


Figure 2-1. AOSS II Component Installation

2.2 MISSION DESCRIPTION

The AOSS II mission is conducted in two modes. In the long range detection mode (Figure 2-2), the SLAR system is used for initial ship detection and for long range spill detection and mapping. Also during long range operation, the passive microwave imager (PMI) scans the SLAR blind-spot area directly beneath the aircraft and performs the same mission functions as the SLAR. For example, at an aircraft altitude of 10,000 feet the SLAR covers a swath width from approximately 1.5 to 25 miles on the left and right sides of the aircraft line of flight. At this altitude the PMI covers a swath approximately 1.5 miles on each side of the aircraft.

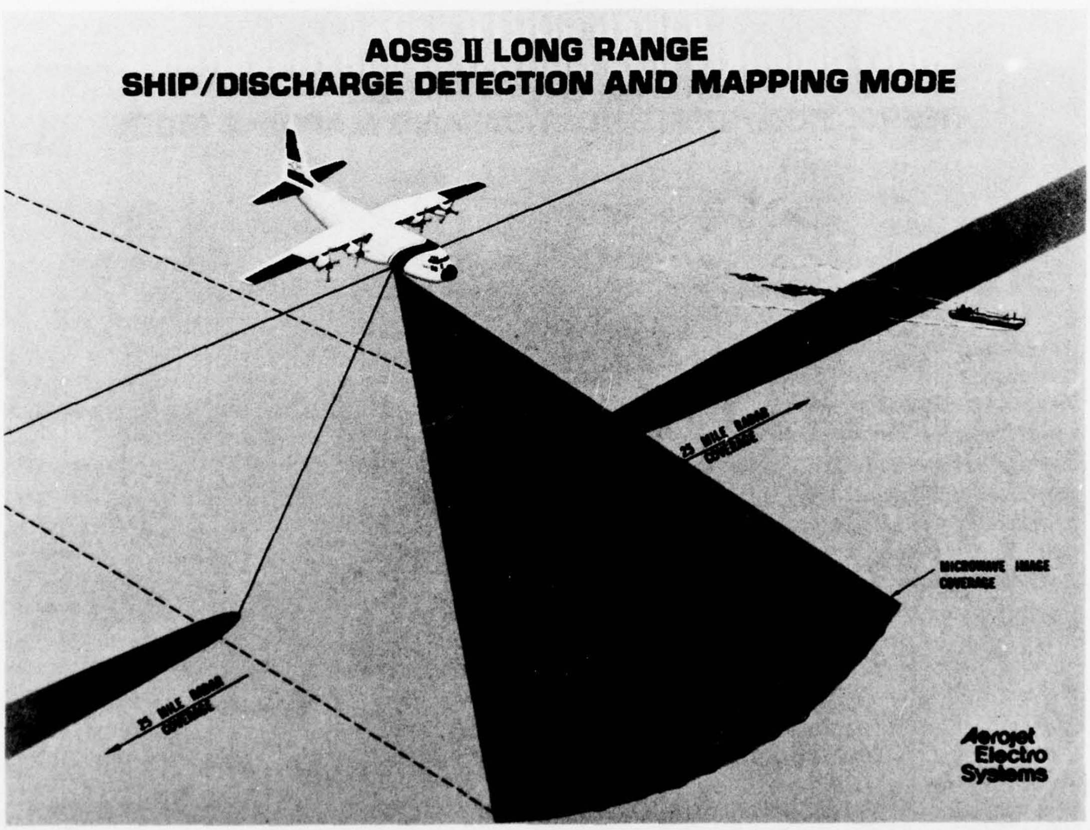


Figure 2-2. Long Range Detection and Mapping Mode, Conceptual View

During the long range detection mode, structured patterns such as expanding squares, rectangles, ladder patterns, or constant bearing off of a reference point can be flown. These patterns provide complete coverage of an area of interest (sea lanes, for example). The inertial navigation system provides the means to fly a particular flight pattern during this type of mission, and the SLAR swath provides the necessary coverage.

If a target of interest is located during the long range detection mode, the short range inspection, identification, and mapping mode (Figure 2-3) is initiated. During the short range mode, the aircraft flies over the target area, and the PMI and/or the line scanner are used as primary sensors. The swath coverage of the PMI and line scanner

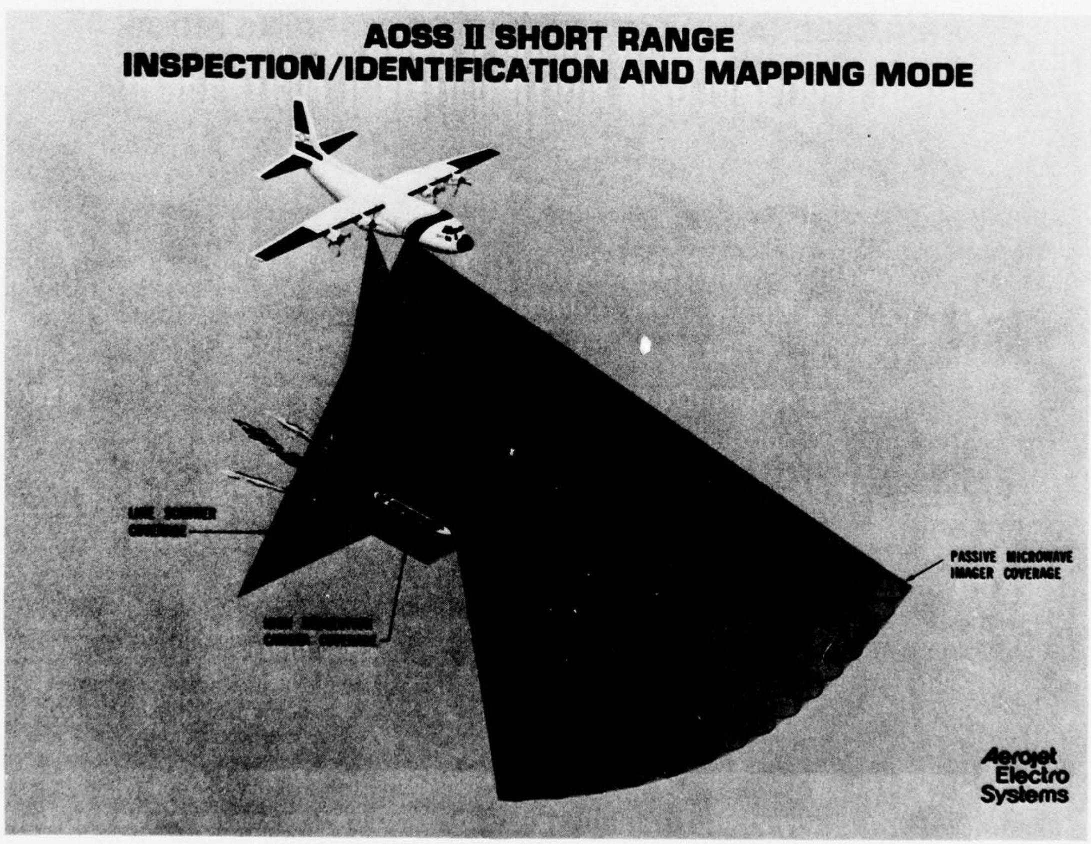


Figure 2-3. Short Range Inspection, Identification, and Mapping Mode, Conceptual View

depends upon altitude. The angular coverage of the PMI is approximately 80 degrees, and the angular coverage of the line scanner is approximately 100 degrees. A KS-72 camera is also available to obtain black and white or color photographic spill documentation during daylight hours.

The surveillance information obtained by the sensors (camera excepted) is available in real-time, and all records are referenced in time and space. The displayed and recorded sensor data are annotated in alphanumeric form as to aircraft position, altitude, flight characteristics, time of day, mission number, and AOSS II operating parameters by the airborne data annotation system (ADAS). The LTN-51 inertial navigation system (INS) provides aircraft positional and attitude data to the ADAS. The INS positional data are also used to determine SLAR target locations along with physically positioning remote water temperature values. The flight attitude data are used to correct the sensor imagery. An altimeter provides the aircraft altitude data needed to compute velocity/height (V/H) ratio signals. The V/H signals control the PMI antenna rotation, determine the number of line scanner and SLAR lines selected for display, and guides the KS-72 camera image motion compensation and film overlap functions.

2.3 EQUIPMENT DESCRIPTION

2.3.1 Aircraft Layout

The locations of the various sensor subsystems in the aircraft are shown in Figure 2-1. The line scanner is mounted in a modified 450 gallon wing fuel pod located on the underside of the left wing. The passive microwave imager is also mounted in a modified 450 gallon wing fuel pod located on the underside of the right wing. Aircraft engine bleed air is circulated through the pods during flight to maintain a suitable operating environment.

The two SLAR antennas are contained in radomes attached to each aircraft wheel well. The SLAR receiver/transmitter (R/T) is

mounted in the overhead lighting trough, as near to the antennas as possible, to minimize waveguide length between the R/T and antennas. The AOSS II console, power supply rack, computer rack, SLAR target indicator, and SLAR equipment rack are installed on a standard C-130 cargo pallet for quick installation and removal. The KS-72 camera is mounted in the after cargo door and protrudes through the aircraft skin into an external enclosure. Two ports are provided in the enclosure for nadir viewing and for viewing at a 45-degree angle to the left. Camera viewing angle can be changed while in flight and access to the film magazine is also possible. All of the AOSS II components, junction boxes, and panels are located as shown in Figure 2-1.

2.3.2 Line Scanner

The line scanner (L.S.) equipment is shown in Figure 2-4. The line scanner consists of the line scanner assembly components which are mounted in the pod, a power supply, a film recorder, and a visicorder oscillograph. The visicorder oscillograph, when combined with the L.S. film recorder, provides a simultaneous film recording capability of any two L.S. data channels. The visicorder oscillograph is mounted in the middle of the SLAR equipment rack. The line scanner is used for oil slick detection and mapping during inspection flights over potential violators. The line scanner operates in the infrared and ultraviolet regions and offers a choice of three detectors. Two of the detectors (Channels 1 and 2) operate in the infrared region, 8 to 13 micrometers, and 8 to 9.5 micrometers. The third channel detects radiation in the UV spectrum from 0.32 to .38 micrometers.

The IR channels of the line scanner detect differences in radiometric brightness temperature. Brightness temperature is a function of the temperature, emissivity, and reflectance of the target area. The IR channels are useful for both day and night operation and provide high resolution pictures without the requirement of illumination.

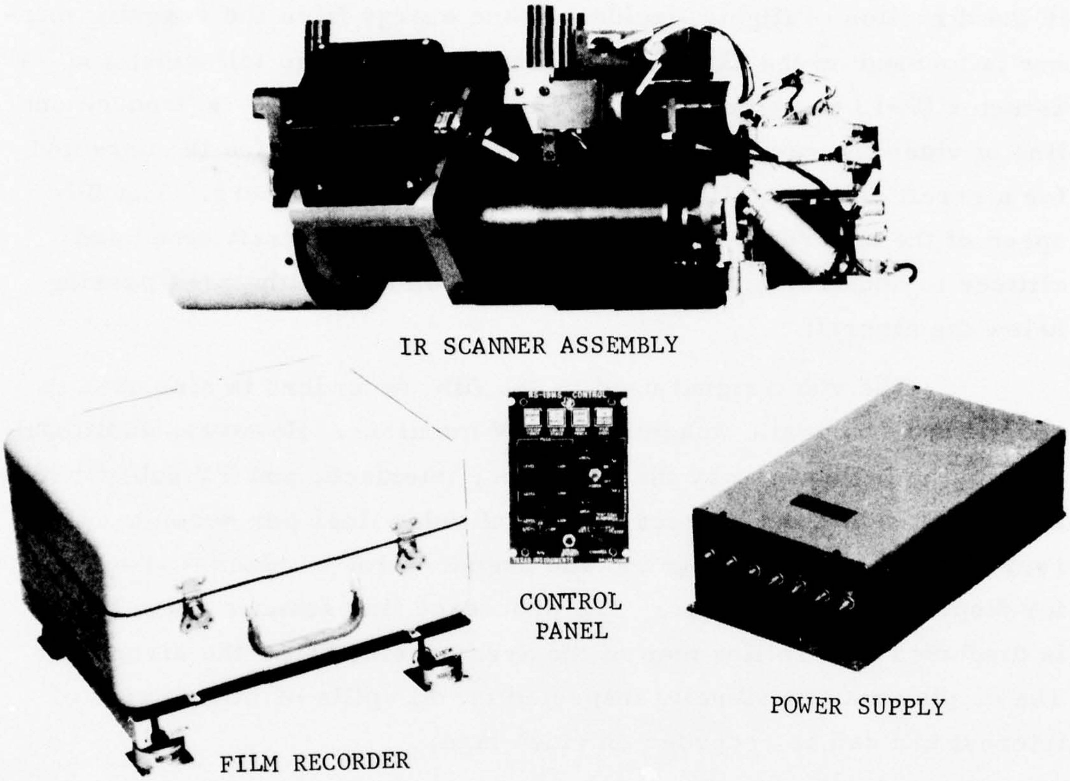


Figure 2-4. Line Scanner Equipment

The UV channel detects solar radiation reflected from the ocean surface. For calm seas, UV detection is based upon the reflection of different UV radiation intensities from an oil slick surface versus a clean water surface. The reflection of certain wavelengths will be prodominant according to the solar radiation condition encountered. This will result in a difference in signal level when an oil slick is being scanned, and the oil slick will appear on the display as a contrasting color or shade of gray. Thus, the UV channel is only useful during daylight when solar radiation is present.

The scene below the aircraft is scanned at 5,000 scans per minute by a flat mirror located in the line scanner. The mirror scans a field 100 degrees across the direction of flight and 2.5 milliradians

in the direction of flight. Incident scene energy from the scanning mirror is focused on the IR detectors (mercury cadmium telluride) and UV detector (P-13 photomultiplier). The IR and UV detectors produce one line of video for each scan of the mirror. The video line is corrected for aircraft roll, amplified, and fed to the film recorders. The film speed of the recorders is varied as a function of aircraft speed and altitude to construct an IR and UV picture on film of the area passing below the aircraft.

The video signal used by the film recorders is also used to construct a composite image on the TV monitors. However, additional processing is required by the computer, interface, and TV subsystem circuits to select the correct number of video lines per second, correct for nonlinear scanning and add pseudo-color or black-and-white for display on the monitors. The processed line scanner video signal is displayed as a rolling map of the area passing below the aircraft. The display may be visually inspected for oil spills or other items of interest and can be recorded on video tape.

Remote sea surface temperature sensing is accomplished by comparing the IR signal to the calibrated signals of two thermoelectrically cooled and/or warmed blackbodies. Due to the effect of the atmosphere on the accuracy of the remote temperature measurements, it is desirable that water temperature measurement be accomplished at low altitudes. The remote temperature is computed by the data processor. A printout of the computed temperature, time, heading, and position is displayed by an offline printer contained in the SLAR equipment rack.

2.3.3 Sidelooking Airborne Radar

The SLAR consists of an OSDR-94 (Oil Slick Detection Radar) and data processor circuits required to produce a TV display and target location. The OSDR-94 radar equipment mounted inside the aircraft is shown in Figure 2-5. The SLAR equipment consists of a receiver/transmitter, signal processor, radar mapping recorder processor viewer (recorder), radar target indicator, sweep

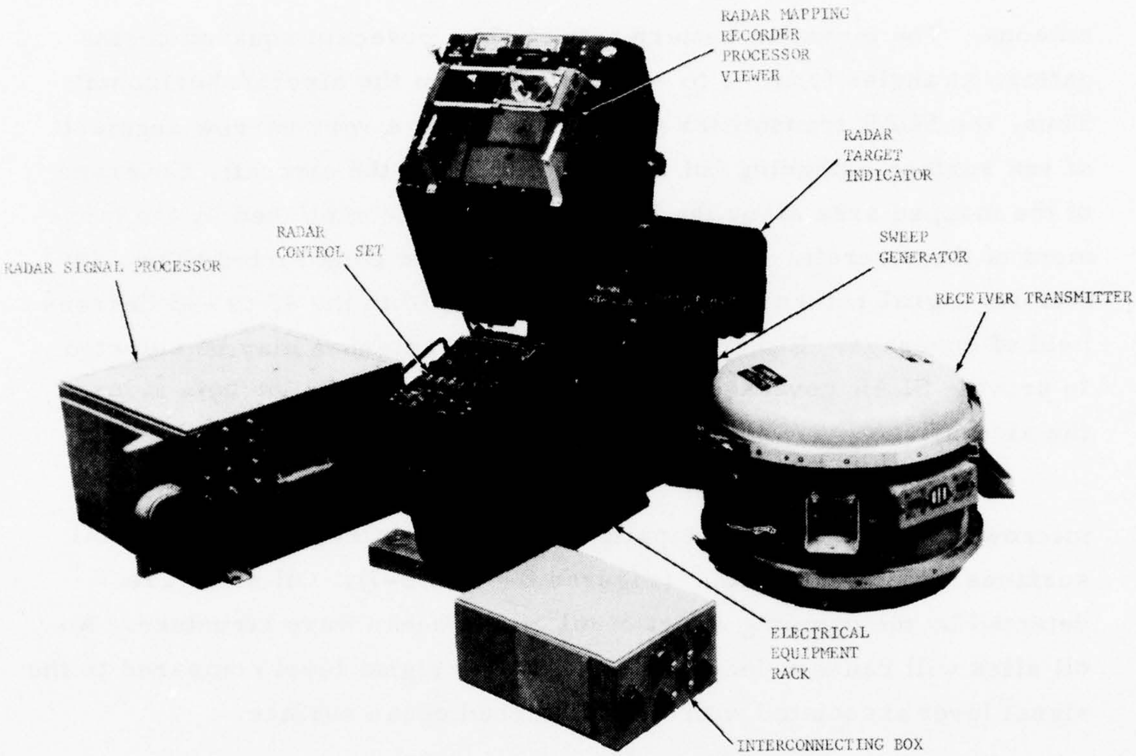


Figure 2-5. SLAR OSDR-94 Components

generator, electrical equipment rack, radar control set, an interconnecting box, a sixteen-foot horizontally polarized antenna and an eight foot vertically polarized antenna.

The radar antennas are stabilized in the yaw axis and are mounted on the left (horizontally polarized) and right (vertically) polarized) sides of the aircraft to provide swath coverage to each side of the aircraft flight path. The swath coverage is a 25- or 50- kilometer range segment which may start at the aircraft line of flight or may be delayed in 10-km steps on each side of the aircraft.

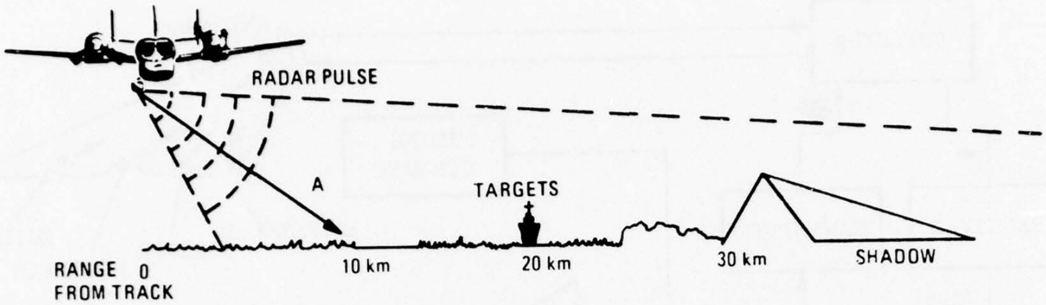
The SLAR beam patterns extend out and down from the sides of the aircraft. The beamwidths in the azimuth direction (i.e., at right angles to the direction of flight) are 0.9 degrees for the vertically polarized antenna and 0.45 degrees for the horizontally polarized

antenna. The elevation pattern extends in a cosecant squared cosine pattern at angles from -3 to -45 degrees from the aircraft horizontal. Thus, the SLAR transmitter pulse illuminates a very narrow segment of sea surface extending out from both sides of the aircraft. Coverage of the mapped area along the line of flight is accomplished by the movement of the aircraft. The antenna patterns are constructed to provide uniform signal return independent of range within the -3 to -45 degrees field of coverage. Either one or both of the antennas may be selected to provide SLAR coverage of the right side, left side, or both sides of the aircraft.

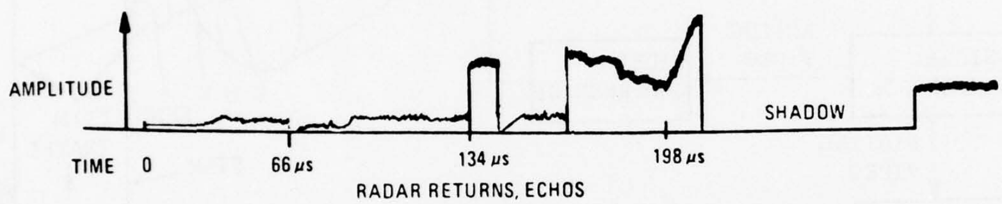
The SLAR system operates by transmitting energy in the microwave spectrum and mapping the energy reflected from physical surfaces in the beam path. (Figures 2-6 and 2-7). Oil sicks are detected by the damping effect of oil on the ocean wave structure. An oil slick will cause a decrease in the radar signal level compared to the signal level associated with an undisturbed ocean surface.

The SLAR provides both a ship and oil slick detection/mapping capability during all but the most inclement weather conditions. A film recorder is mounted on the front of the target indicator and constructs a radar map from the single-line intensity-modulated video displays. The left side of the film recorded image represents information from the left antenna, and the right side of the film recorded image represents information from the right antenna. Range, fiducial marks, and annotation data are generated and added to the video recorded signal to indicate the position of the radar target relative to the radar map. A magnifier is attached to permit magnification of selected portions of the photoradar map.

The SLAR video signal can also be displayed on the TV monitors as a rolling map display. To produce a composite TV picture of the one-line radar display, the video signals are processed through the data processor and displayed on the monitors in black and white



A. SLANT RANGE, MEASURED BY RADAR



NOTE: ABSENCE OF RETURNS FROM SHADOW AREA

B. RADAR RETURNS, ECHOS

C. EXPANDED TRACE ON CRT SHOWING LIGHT OUTPUT PRODUCED BY ECHOS SHOWN IN "B" ABOVE

Figure 2-6. SLAR Recording Relationships

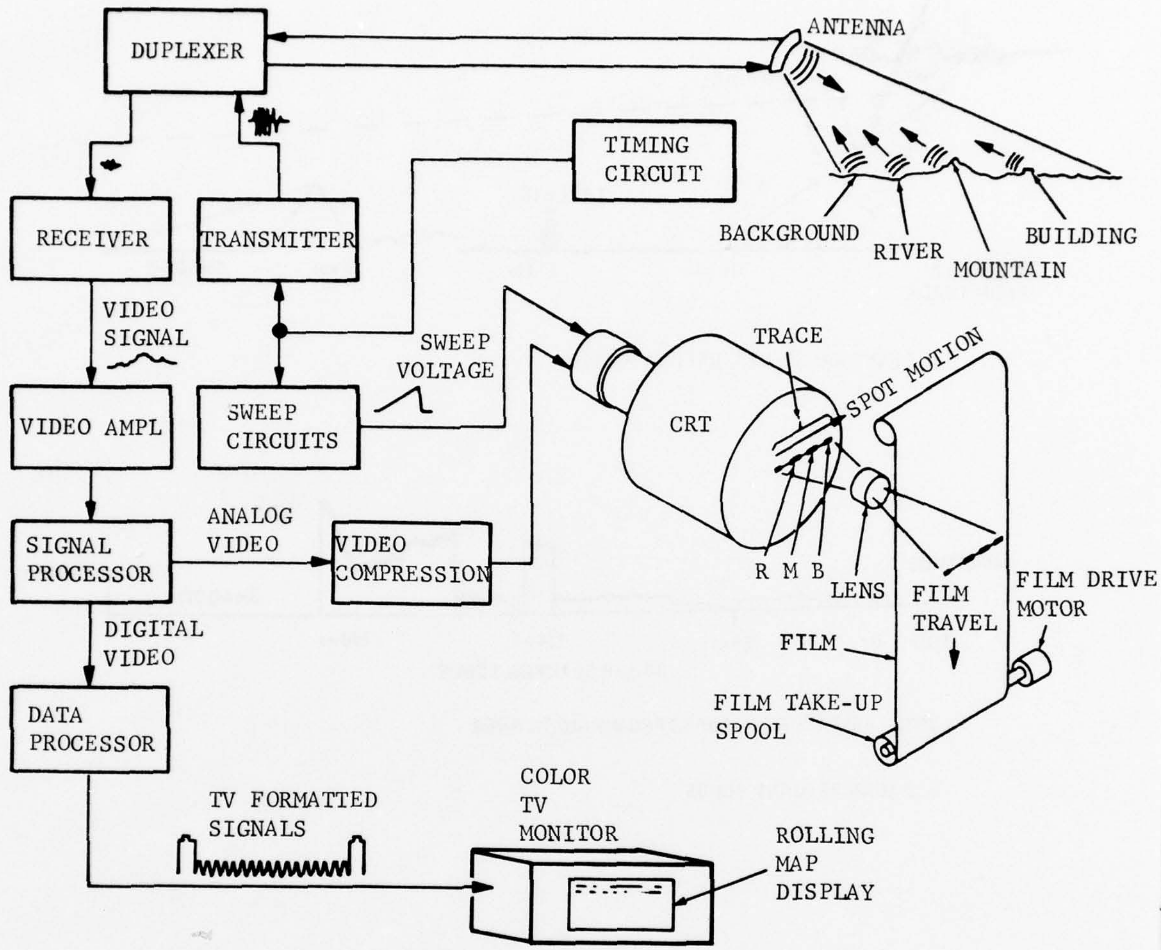


Figure 2-7. SLAR Mapping Operation Block Diagram

or color. The displayed image is scaled in amplitude, corrected for slant range, squint angle, and yaw (for both the right and left antennas). The processed signal may be displayed as a rolling map of the area on either or both sides of the aircraft as desired by the operator. A threshold alarm setting is also provided so that signals that exceed the threshold will flash intermittently on the TV display. The image displayed on the TV monitor may also be recorded on video tape.

As SLAR targets appear on the TV monitors, the targets may be cursored with subsequent positional data in the form of latitude and

longitude coordinates being displayed on the TV annotation graphics and offline printer. The target cursor/location feature requires positional input data from the INS and is accomplished by use of thumbwheel switches located on the data processor console.

2.3.4 Passive Microwave Imager

The passive microwave imager (PMI) subsystem consists of the PMI assembly and data processing circuits required for TV display and video tape recording. As shown in Figure 2-8, the PMI assembly consists of an antenna, RF section, signal processing section, rotating mechanism, driver box, and servo amplifier. There are no switches or controls located on the PMI. The PMI operates automatically when the circuit breaker on the power distribution panel is turned on.

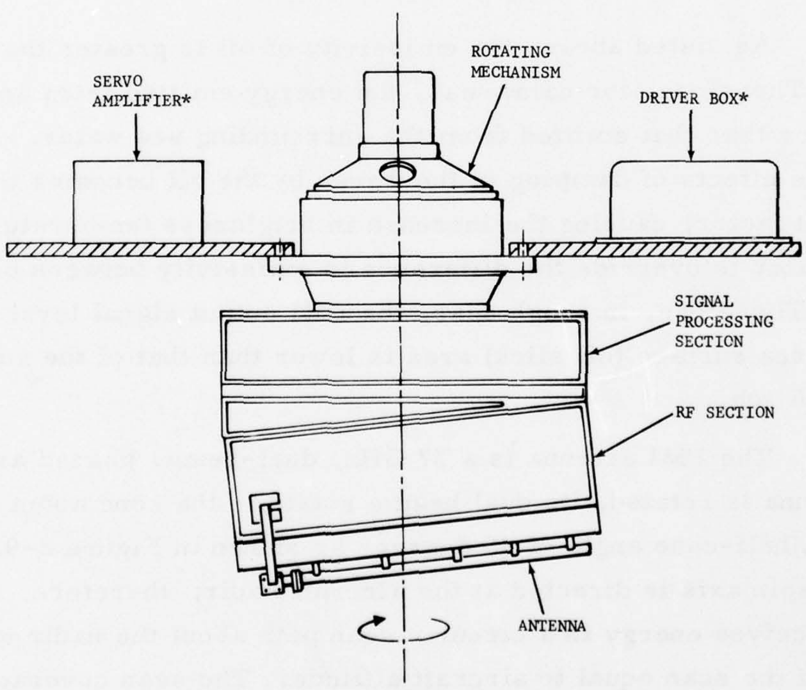


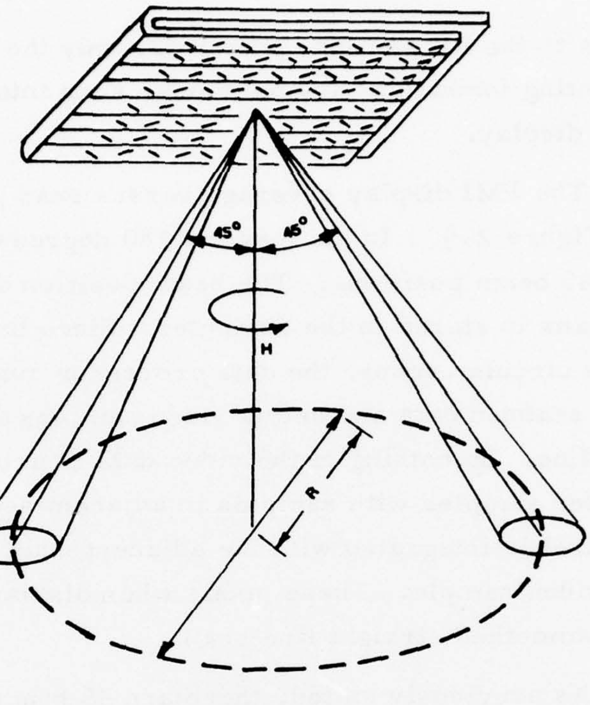
Figure 2-8. Passive Microwave Imager

The functions of the PMI subsystem are to (1) provide adverse-weather, day/night ship and oil slick detection in a swath approximately ±40 degrees beneath the aircraft not covered by the SLAR and (2) provide oil-slick mapping and spill confirmation during short range inspection and mapping operations.

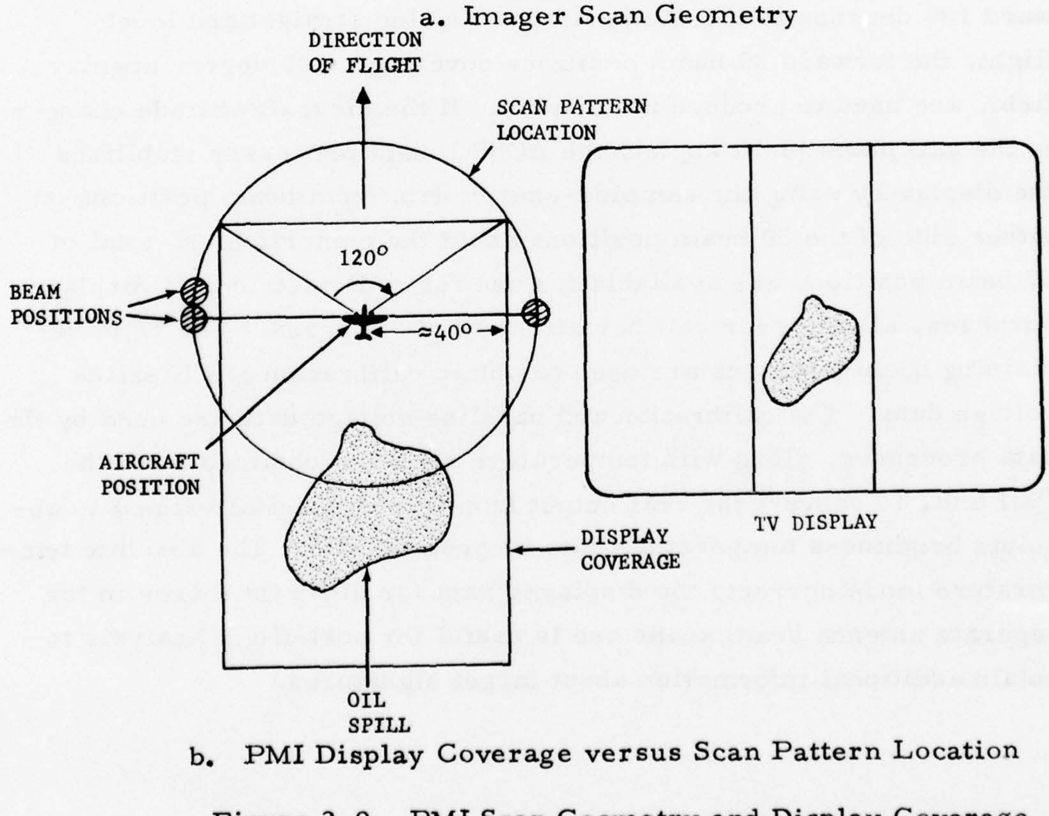
The PMI measures and maps natural microwave radiation emitted and reflected from the water surface. Microwave emission is dependent upon the electrical properties of the target of interest and is independent of time of day. Water has a low emissivity whereas oil has a high emissivity. Therefore, the PMI is quite sensitive to oil slicks on the water surface. Microwave radiation is measured as apparent brightness temperature. Brightness temperature is a function of the temperature, emissivity, and reflectance of the target area and sky radiation level over the target area.

As stated above, the emissivity of oil is greater than that of water. Therefore, for calm seas, the energy emitted from an oil slick is greater than that emitted from the surrounding sea water. For rough seas, the effects of damping of the waves by the oil becomes the predominant factor, causing the increase in brightness temperature of the rough water to override the difference in emissivity between oil and water. Therefore, in rough seas, the PMI output signal level for the damped sea surface (oil slick) area is lower than that of the surrounding rough sea.

The PMI antenna is a 37 GHz, dual-beam, phased array. As the antenna is rotated, its dual beams rotate in the cone about the spin axis at a half-cone angle of 45 degrees as shown in Figure 2-9. The imager spin axis is directed at the aircraft nadir; therefore, the antenna receives energy in a circular scan path about the nadir with the radius of the scan equal to aircraft altitude. The scan coverage of the imager is therefore a direct function of aircraft altitude. The energy from each of the dual beams is applied through separate



a. Imager Scan Geometry



b. PMI Display Coverage versus Scan Pattern Location

Figure 2-9. PMI Scan Geometry and Display Coverage

waveguides to the RF section. However, only the energy of the beam that is pointing forward at any particular scan interval is used for producing the display.

The PMI display coverage versus scan pattern location is also shown in Figure 2-9. In the forward 180 degrees of the scan pattern, there are 45 beam positions. The beam position data received for eight antenna scans is stored in the computer. Since this beam position data represents circular scans, the data processor must slice through the circularly scanned data and select video samples (pixels) representing a straight line. Smoothing of the video data is accomplished by integrating video samples with samples in adjacent scan lines. Thus, the selected pixel is integrated with the adjacent scan lines to create one averaged video sample. These pixels when displayed on the TV monitor produce a smoothed straight line scan.

As previously stated, there are 45 beam positions in the forward 180 degrees of the scan pattern. During straight and level flight, the forward 30 beam positions covering a 120 degree angular field, are used to produce the display. If the aircraft attitude changes in the yaw plane (drift angle), the AOSS II data processor stabilizes the display by using the sampled-energy data from beam positions on either side of the 30 beam positions about the centerline. A total of 37 beam positions are available for use for radiometric data display purposes, allowing for yaw deviations of ± 10 degrees. The eight remaining beam positions are used to obtain calibration and baseline voltage data. The calibration and baseline voltage data are used by the data processor, along with temperature readouts obtained from the PMI unit, to convert the PMI output from counts (digital values) to absolute brightness temperature data (degree Kelvin). The absolute temperature mode corrects the displayed data for different losses in the separate antenna beam scans and is useful for post-flight analysis to obtain additional information about target signatures.

The display is a rolling linear map from the top to the bottom of the TV screen. Only one fourth of the screen width, in the center of the screen, is used for displaying the PMI image. This lengthens the flight-path dimension on the screen and thereby extends the display time of the area of interest.

The rotating mechanism, servo amplifier, and driver box circuitry control the PMI scan operation. Scan rates range from 8 to 88 rpm depending on V/H values supplies by the data processor. The driver box also contains line driver circuits that transfer signals to the data processor and receive signals from the data processor.

Raw data from the PMI is recorded automatically on one of the audio tracks of the video tape recorder (VTR) for subsequent display and analysis. The transmission of the data to the VTR and its playback to the computer are accomplished by pulse coded modulation (PCM) interface circuitry. When the PMI system is selected for "live" display, or when data is being played back using the PCM interface, the data is manipulated by the computer and TV subsystem to prepare it for TV monitor display. The PMI data for "live" display is transferred to the data processor via the imager interface.

The PMI has good sensitivity to oil spills and provides around-the-clock and adverse weather detection capability. The PMI is also useful for obtaining qualitative information concerning major oil spills, such as approximate oil film thickness. PMI resolution is adequate for ship detection during the routine oil surveillance patrol missions and for the mapping of moderate to large oil spills.

2.3.5 KS-72 Camera

The KS-72 camera (Figure 2-10) is mounted in the after cargo door and protrudes through the aircraft skin into an external enclosure. Two ports are provided in the enclosure for nadir viewing and for viewing at an angle of 45 degrees to the left. In the nadir position, the area photographed by the KS-72 is basically the center

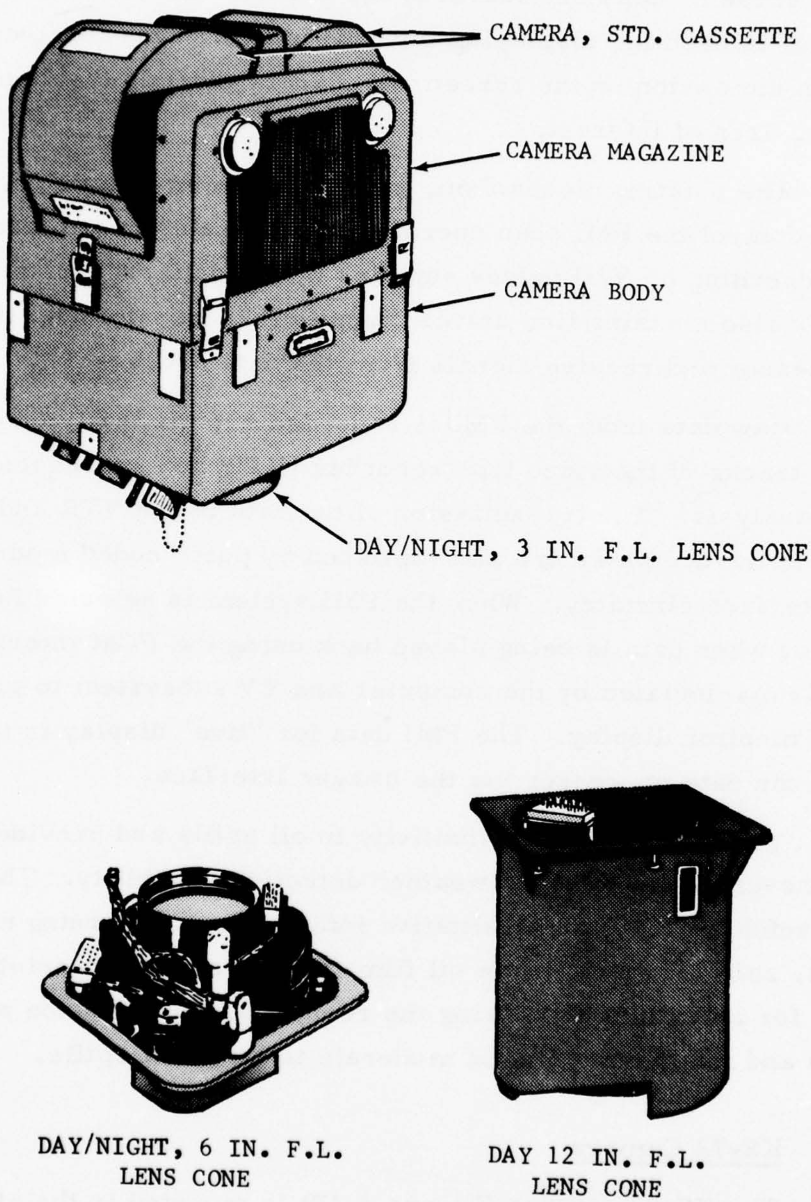


Figure 2-10. KS-72 Camera

portion of the L. S. and PMI sensor fields of view. A three-inch lens (F.O.V. = 73°44'), a six-inch lens (F.O.V. = 41° 0.6') or a twelve-inch lens (F.O.V. = 21° 41') can be selected for use with the camera. The camera pointing position and film can be changed in flight.

The KS-72 camera takes sequential photographs with a selection of 12 or 56 percent overlap on each photograph. The number of photographs per second is determined by the aircraft V/H ratio with a maximum of six frames per second. Photographs can be made at a single frame rate or at the maximum rate and may be taken with or without image motion compensation (IMC). A film footage counter on the camera control panel indicates the amount of film used. An automatic exposure control with compensation for cloud coverage is also available on the camera control panel.

Annotation data provided by the ADAS is printed on each photo for identification purposes. The KS-72 camera is limited to daylight operation. Night photos are possible with pyrotechnie flares or strobe lights for illumination (not provided on AOSS II).

2.3.6 Inertial Navigation System

A Litton LTN-51 Inertial Navigation System (INS) is used to assist in navigation of the aircraft. In addition to its aircraft navigation mission, the INS plays an important role in the AOSS II data annotation and sensor control functions. The system operates by sensing aircraft accelerations from a gyro-stabilized, four-gimbal, all-attitude platform. Output functions of the system include accurate present-position (latitude/longitude) information; course-line computation; steering commands; and angular pitch, roll, and heading information. In addition, the INS has been modified to mechanize three standard search patterns into the system capability to allow automatic navigation and auto-piloting of the aircraft during search pattern flying. The navigation and guidance computations are performed by a microelectronic, general-purpose digital computer. The computer steering

commands are referenced to great-circle routes between the desired waypoint coordinates. Unrestricted worldwide navigation is provided by a wander-azimuth technique, which eliminates the ambiguities normally associated with navigation in the polar regions.

The INS supplies aircraft ground speed, position, heading, pitch, roll, and yaw data. These signals are routed to the AOSS II airborne data annotation system (ADAS) together with altitude data from an altimeter.

The ADAS produces a time reference and formats the data received from the INS and altimeter for application to the computer. The navigation/SLAR interface extracts ground speed and drift angle data from the inertial navigation system serial data and applies this information to the SLAR film recorder for control of film speed. The sensors also receive signals from the computer via the sensor interfaces to control sensor performance according to AOSS II operating parameters and aircraft flight parameters (speed, altitude, pitch, roll, and yaw) that are derived from the INS.

The system, as supplied to the Coast Guard for the HC-130B aircraft, consists of the following components, located in the aircraft as noted:

Unit	Location
Mode Selector Unit	Navigator's Station
Search Mode Unit	Navigator's Station
Control/Display Unit	Navigator's Station
Autopilot Controller	Cockpit Center Pedestal
Battery Unit	Right Forward Compartment
Inertial Navigation Unit	Right Forward Compartment

Figure 2-11 gives an overall block diagram of the INS as installed in the AOSS II aircraft.

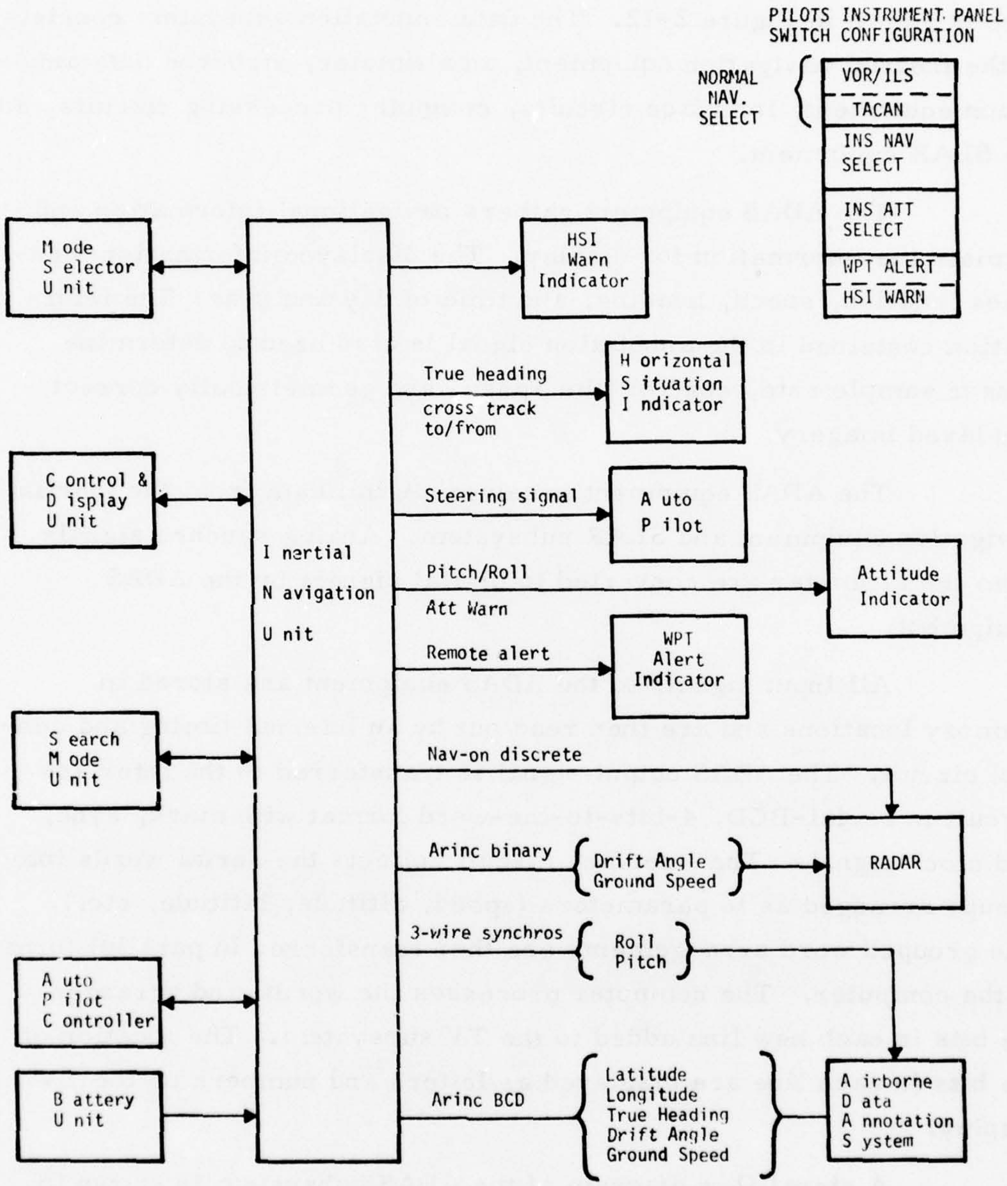


Figure 2-11. INS Block Diagram

2.3.7 Airborne Data Annotation System

A simplified diagram of the data annotation subsystem interface is shown in Figure 2-12. The data annotation subsystem consists of the inertial navigation equipment, an altimeter, airborne data annotation equipment, interface circuits, computer processing circuits, and the SLAR equipment.

The ADAS equipment gathers navigational information and formats the information for display. The displayed information identifies location, speed, heading, and time of day and year. The information contained in the annotation signal is also used to determine sensor sample rate, control film speed, and geometrically correct displayed imagery.

The ADAS equipment receives digital data from the inertial navigation equipment and SLAR subsystem. Analog synchro signals from the altimeter are converted to digital signals by the ADAS equipment.

All input signals to the ADAS equipment are stored in memory locations and are then read out by an internal timing and control circuit. The ADAS output signal is transferred to the interface circuit in serial-BCD, 4-bits-to-the-word format with mark, sync, and clock signals. The interface circuit collects the serial words into groups arranged as to parameters (speed, altitude, latitude, etc.). The grouped word arrangements are then transferred in parallel form to the computer. The computer processes the words and arranges the bits in each new line added to the TV subsystem. The location of the bits in each line are displayed as letters and numbers on the TV display.

A signal flow diagram of the ADAS subsystem is shown in Figure 2-13. Navigation data from the inertial navigation system is transferred to the data processor and SLAR film recorder through the ADAS subsystem. The navigation signals are used for the following purposes:

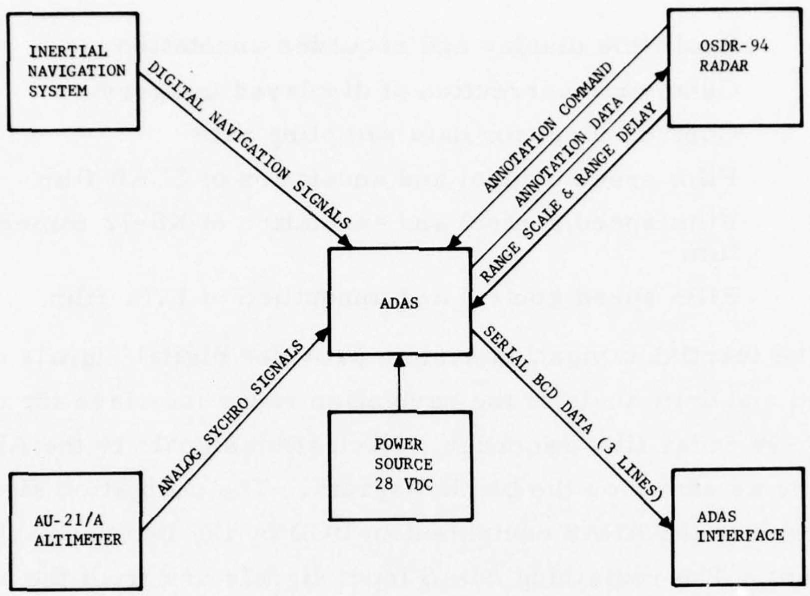


Figure 2-12. ADAS Interface Block Diagram

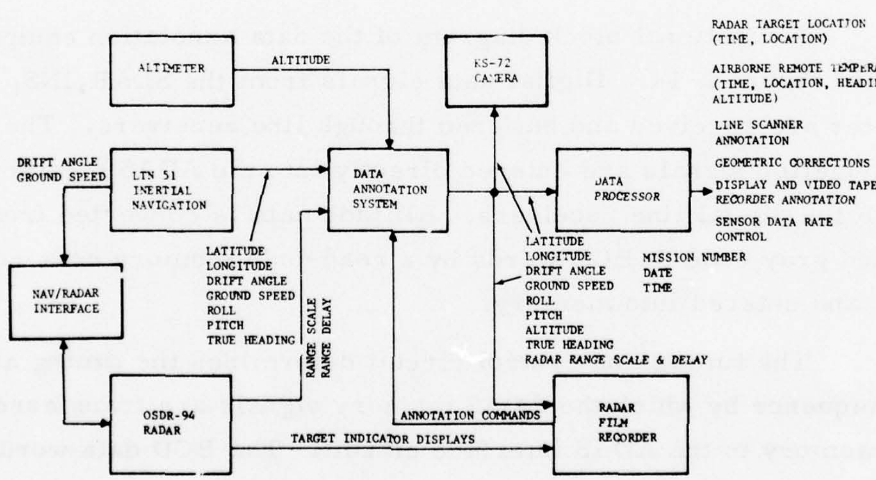


Figure 2-13. INS-ADAS Signal Processor Signal Flow

- Real time display and recorder annotation
- Geometric correction of displayed imagery
- Control of sensor data sampling rate
- Film speed control and annotation of SLAR film
- Film speed control and annotation of KS-72 camera film
- Film speed control and annotation of L.S. film

The inertial navigation system provides digital signals of ground speed and drift angle to the navigation radar interface for use by the OSDR-94 radar film recorder. Navigation signals to the ADAS equipment are as shown on the block diagram. The navigation signals are transferred to the ADAS equipment in BCD by the inertial navigation equipment. The remaining ADAS input signals are from the altimeter and SLAR subsystem. The altimeter provides a modified gray code signal that is converted to four BCD words by the ADAS equipment. The SLAR supplies range scale and range delay signals for use in annotation display.

A functional block diagram of the data annotation equipment is shown in Figure 2-14. Digital data signals from the SLAR, INS, and altimeter are received and buffered through line receivers. The radar and navigation signals are entered directly into the ADAS memory through the digital line receivers. Altitude data is converted from a modified gray code to BCD words by a read-only memory code converter and entered into memory.

The timing and control circuit determines the timing and word sequence by which the ADAS memory signals are transferred from memory to the ADAS interface circuit. The BCD data words pass through the transmission circuits and line drivers to the ADAS interface circuit at the rate of 20 frames per second.

The CRT character generator converts BCD data words from the ADAS memory into numeric characters to intensity modulate

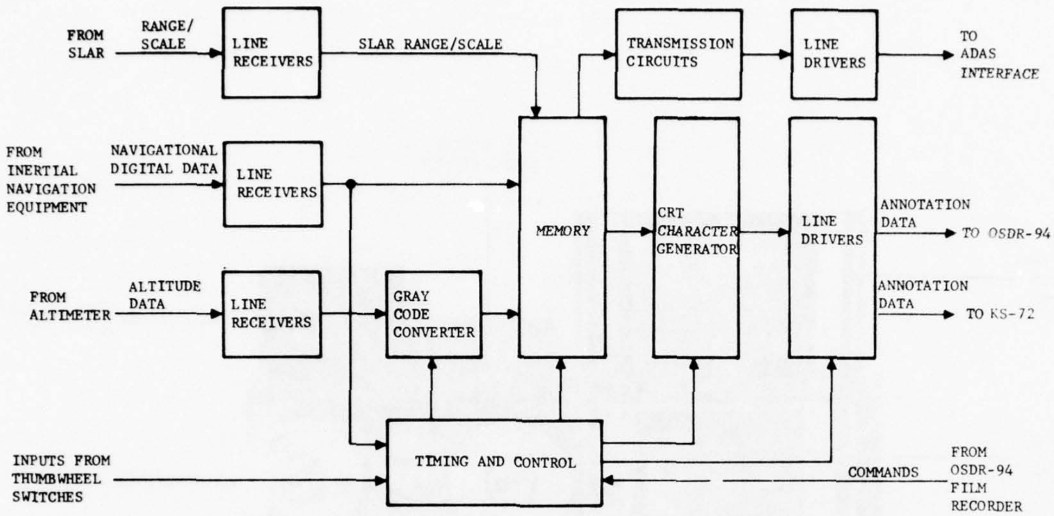


Figure 2-14. ADAS Functional Block Diagram

the ADAS CRT in the radar film recorder and KS-72 camera. The CRT character generator output signals are transmitted to the ADAS CRT in the radar film recorder and KS-72 camera through line driver circuits.

2.3.8 Data Processor

The data processor circuits occupy portions of the data processor console (Figure 2-15) and the computer console (Figure 2-16). The data processor equipment mounted in the data processor console is the refresh memory power supply, operator control panel, computer control panel, color encoder, and interface. The computer enclosure contains the Rolm computer chassis, expansion chassis and refresh memory interface.

The data processor couples the various sensor subsystems to the computer and couples the computer to the displays and recorders. The data processor interface circuits format and condition the sensor signals so that the computer can receive and process the signals. The processed signals from the computer are converted by the data processor circuits into color or black-and-white signals for application to

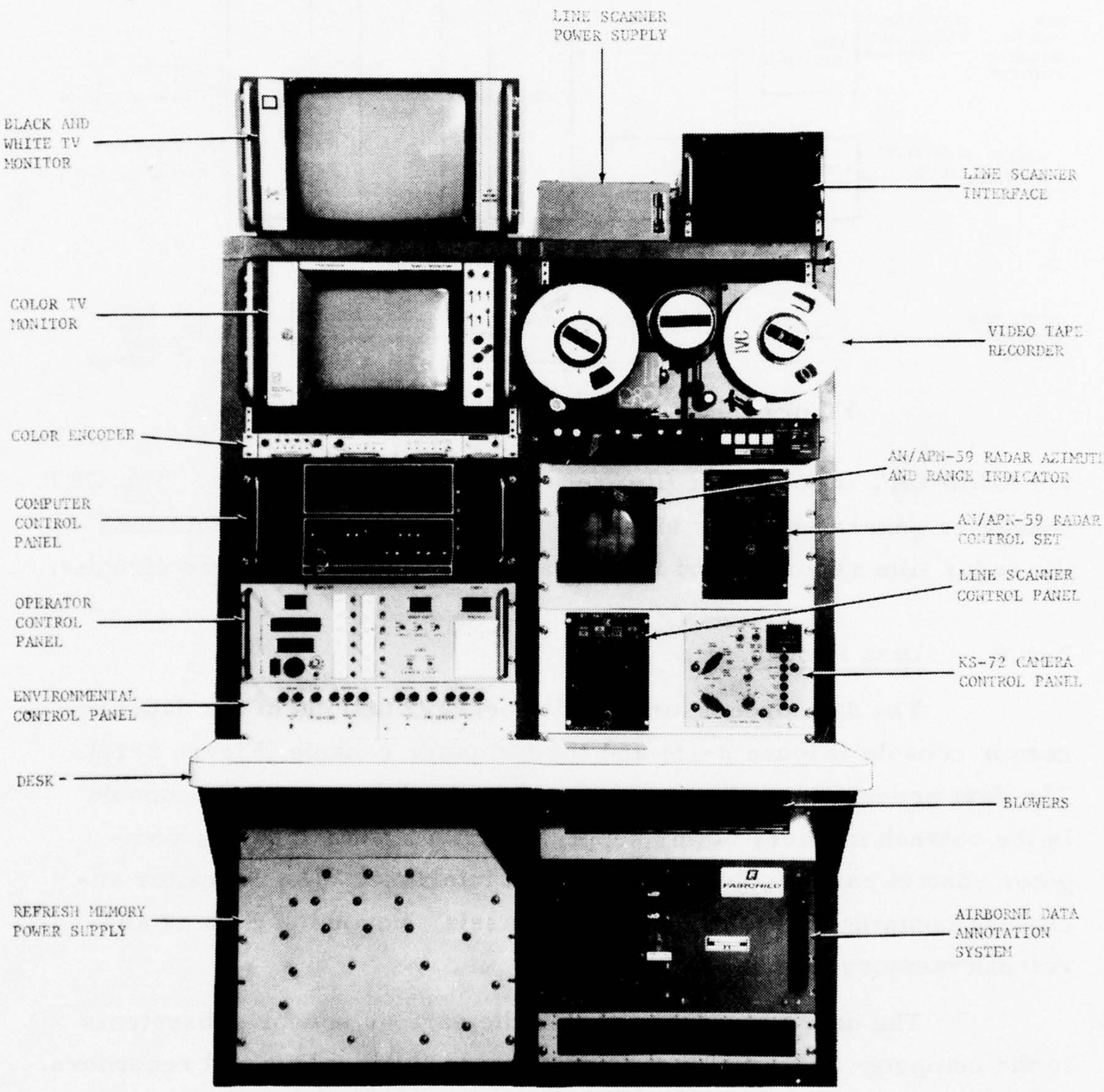


Figure 2-15. Data Processor Console

the TV monitors. Data annotation signals are also processed through the computer and data processor interface circuits for display on the TV monitors. Video tape recordings and playback to the TV monitor are also accomplished through the data processor circuits.

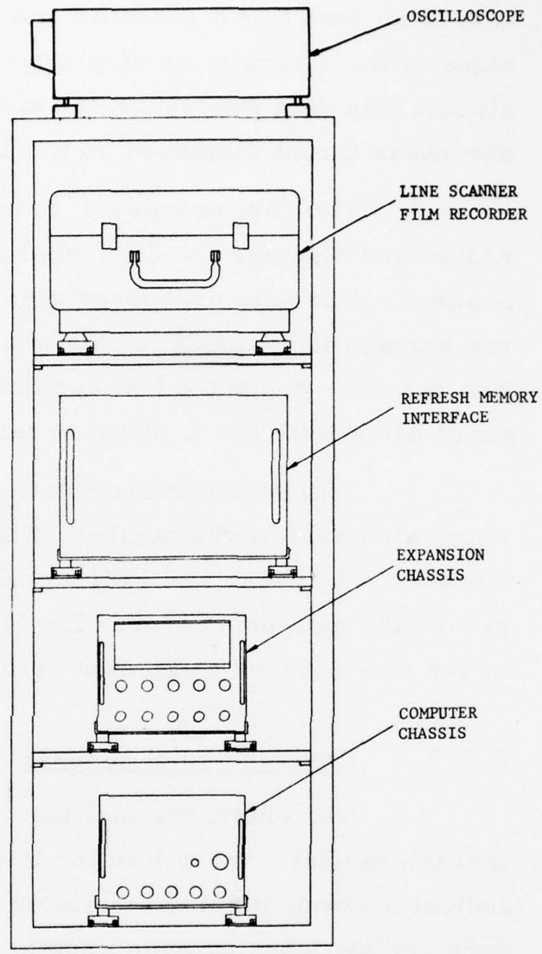


Figure 2-16. Computer Enclosure

The data processor circuits correct for the circular, slant range, and nonlinear scans of the various sensors and displays the processed signals in a linear map form on the TV monitors. The data processor selects the sensor for display, provides pseudo-color for color coding if desired, and monitors signal processing to assure data are within limits. Radar signals that exceed threshold processing limits trigger visual and audible alarms. Radar signals that exceed threshold are also displayed by the data processor as blinking colors on the color monitor if the radar sensor is selected for display and the color display mode is selected.

The data processor scales SLAR and PMI signals up or down to enhance the video image as desired by the operator. The operator may cause the data processor to display the first or last half of the SLAR swath across the entire TV monitor which effectively cuts the range of the selected SLAR swath in half and provides twice the resolution of the normal search mode. The data processor also processes

data from both SLAR antennas and displays the SLAR swath on both sides of the aircraft, or displays only the left or right swath as desired. The data processor can also determine the target location of any radar target displayed on the TV monitor.

The data processor converts the PMI signals to degrees Kelvin and displays the converted signals as an image of the area scanned. The data processor also converts the IR video signals into sea surface temperatures obtained directly below the aircraft. The line scanner computed sea surface temperatures are printed on paper along with time, position data, altitude, and aircraft heading.

The PMI antenna rotation is controlled by the data processor which also selects the number of line scanner and radar lines used for display. The radar and PMI signals are also corrected for aircraft yaw by the data processor. The line scanner signals are stabilized by the line scanner equipment before processing by the data processor.

2.3.9 Environmental Control

The environmental control panel allows the operator to control the temperature within the line scanner and PMI sensor pods. Indicator lamps display the status of the temperature within the sensor pods and switches provide control of the ram air and bleed air. Hot bleed air from the aircraft engines is used to heat the pods and ram air is used to cool the pod interiors.

Engine bleed air is passed through a solenoid operated, on-off pressure regulator to drop the bleed air pressure to 15 psi. This air is then ducted to an air ejector where the hot bleed air is mixed with pod air in a ratio of about 10 parts induced air to 1 part bleed air. This mixture passes through the ejector section and is directed toward the IR line scanner (or PMI) instrument. Limit sensors (thermostats) on the instruments turn the bleed air supply on or off by means of a solenoid. If the instrument temperature drops below 55°F the bleed air is turned on. When the instrument temperature reaches 90°F

the bleed air is shut off. Consequently, the bleed air supply will cycle on and off as the thermal switches are activated. An exhaust port is provided at the aft pod boat-tail to prevent over-pressurization of the pod. In the event that the outside ambient conditions are such that cooling is required (i.e., instrument temperature above approximately 110°F), the bleed air supply would of course be off, but in addition, a second thermostat on the instrument will open a valve in a ram air duct allowing outside air to flow through the pod, until such time as the instrument drops in temperature to approximately 70°F at which time the ram air valve is shut. Heat losses from the pod are limited by a 1-inch thick fiberglass insulation on the pod skin interior.

2.3.10 Forward Looking Radar

Radar set AN/APN-59B is a small, lightweight, X-band airborne radar system designed to operate as a navigational and search radar, a weather radar, or a racon (beacon) interrogator-receiver. The azimuth and range indicator unit functions as a plan position indicator (PPI) with the center of the cathode ray tube representing the aircraft position. Radar set AN/APN-59B is part of the aircraft equipment and is not included as part of the AOSS II equipment. The only relationship with AOSS II equipment is that the control panel and azimuth and range indicator units are installed in the data processor console. The AN/APN-59B operates completely independent of the AOSS II equipment. There is no power drawn from the AOSS II circuit breaker panel and there are no interconnecting cables between components of AOSS II and the AN/APN-59B.

When the AN/APN-59B is used as a search radar, the PPI displays a visual map-like picture showing cities and smaller terrain, rivers, islands, shore lines and ships at sea. Circular range markers provide distance to targets and an azimuth ring provides target bearing information. For short ranges, a fan-shaped vertical antenna

radiation pattern is employed. For long ranges, or low altitude flights, a pencil radiation beam is available. Various antenna speeds, sector scan and a range delayed sweep are also available to aid in the search mode.

During weather surveillance (WARN mode of operation), the PPI functions the same as during the search mode, except that the radar picks up less substantial objects such as storm fronts, heavy rainfall, or other turbulent weather features with precipitation. The difference in operation during weather surveillance is that the transmitter radiates a wider transmitter pulse and the antenna normally operates in the pencil beam radiation pattern. Additionally, the antenna may be set to sector scan an area across the aircraft heading and the antenna beam may be tilted to examine the vertical extent of a storm or a mountain.

The beacon mode is a specialized navigation function of the forward looking radar. Ground based navigation beacons operate in the X-band and transmit pulse coded signals when triggered by the radar transmitter. In the beacon mode, the PPI does not display a radar map. Instead, groups of bars spaced according to the identification code of the navigation beacon are displayed at the range and azimuth of the beacon location.

2.3.11 SLAR Equipment Rack

The SLAR equipment rack is shown in Figure 2-17. The SLAR equipment rack contains the SLAR signal processor, SLAR interconnecting box, visicorder oscillograph, and offline printer. The visicorder oscillograph presents a visual display of the selected IR or UV L.S. channel. The visual display appears on processed paper (or film) which is fed out the top of the recorder. The offline printer, prints the water temperature or the SLAR target location as selected by switches on the operator control panel. The SLAR signal processor and SLAR interconnecting box are part of the sidelooking airborne radar equipment.

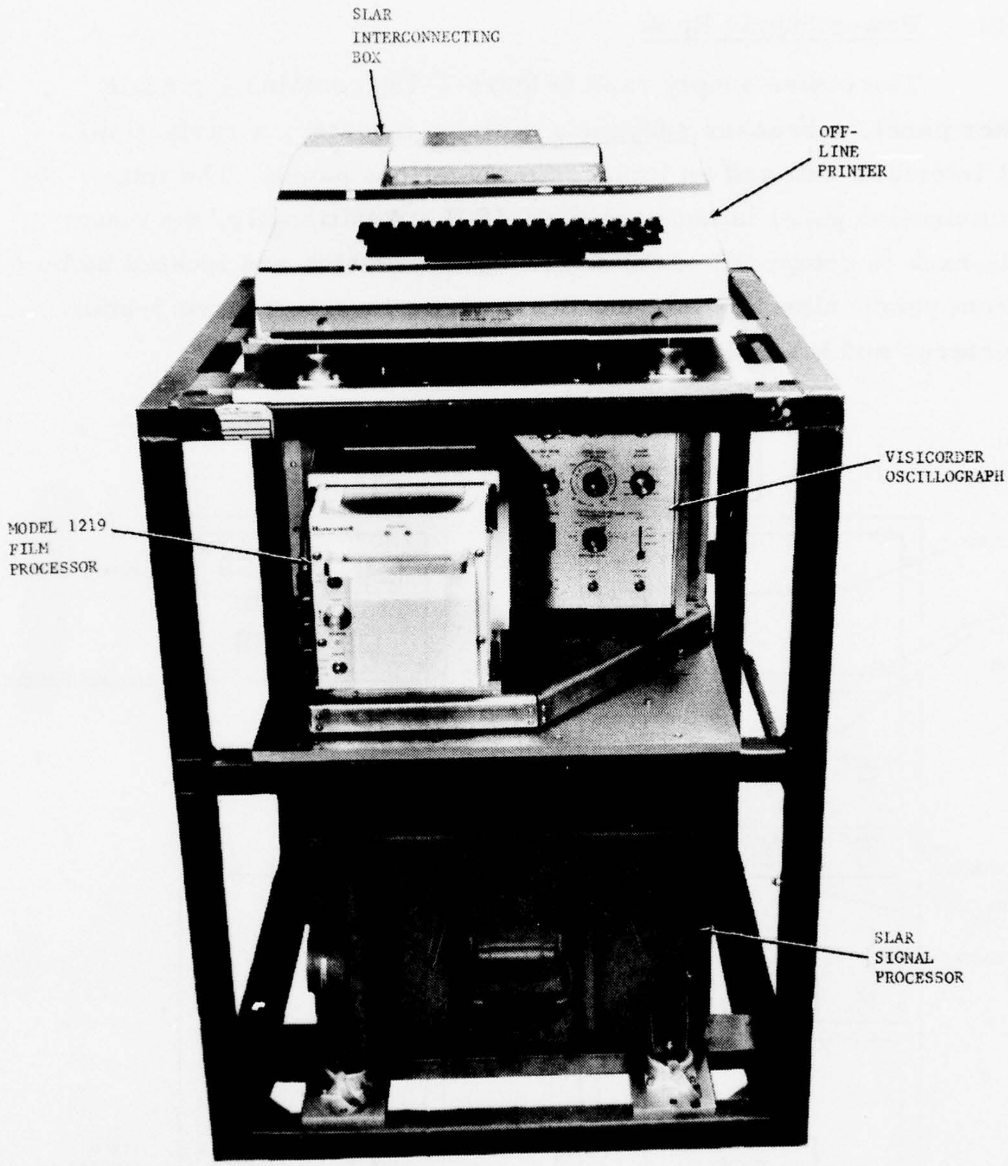


Figure 2-17. SLAR Equipment Rack

2.3.12 Power Supply Rack

The power supply rack (Figure 2-18) contains a circuit breaker panel, a breaker subpanel, a static inverter, a navigation/SLAR interface unit and an intercommunications panel. The inter-communication panel is not part of AOSS II. Additionally, the power supply rack is composed of the following units which are located below the front panel: nine 115 volt 400 Hertz static inverters, two 3-phase converters, and a regulated +28 volt power supply.

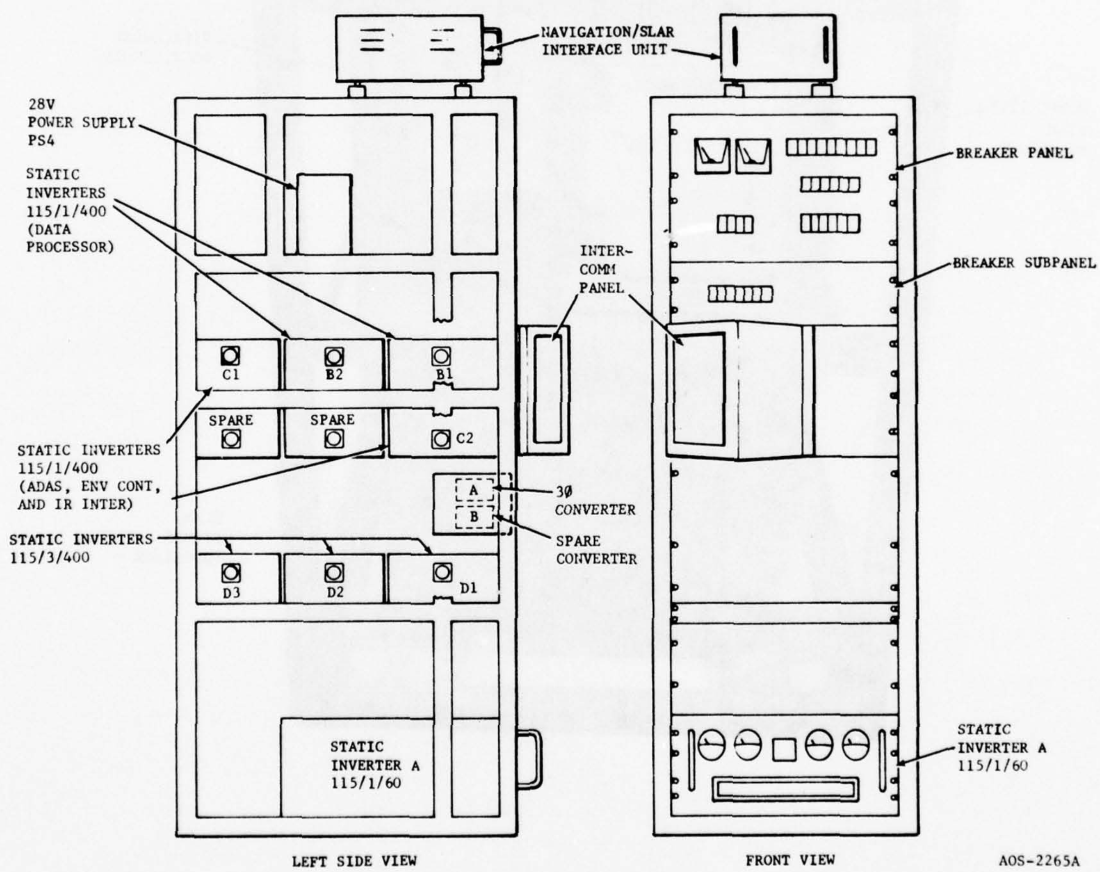


Figure 2-18. Power Supply Rack

The breaker panels control power distribution to the AOSS II equipment. Unregulated 28-volt power from the aircraft is applied through circuit breakers to the inverters. Static inverter pairs B1 and B2 and C1 and C2 each provide a source of 115V/1Ø 400 Hz power. Static inverters D1, D2, and D3 in conjunction with 3Ø converter A produce 115V/3Ø/400 Hz. Two static inverters and a 3 Ø converter are provided as spares. The regulated +28 Vdc power supply receives 115V/1Ø 400 Hz input power from static inverter A.

2.4 SYSTEM FEATURES

2.4.1 Equipment Interconnection

The basic interconnections between the AOSS II subsystems are shown in Figure 2-19. As shown, AOSS II is divided into three major segments: sensors, data processor, and display/recorders. The data processor is further divided into three groups of equipment: sensor interface circuits, computer, and display interface circuits. The sensor outputs are fed through the sensor interfaces to either the computer, in the case of the SLAR system and PMI, or directly to the display interface, in the case of the line scanner. The computer outputs and other image data are applied to the display/recorder equipment via the display interface circuitry.

2.4.2 Line Scanner Data Processing

The line scanner image data is not applied to the computer, but the line scanner interfaces with the computer to receive scan sample rate data based on aircraft altitude and speed. The sampled image signal is converted to digital data and processed by the interface circuit to provide a linear left-to-right scan. The processed IR/UV video signal is then applied to the TV subsystem for further processing. The TV subsystem formats the IR/UV image data for application to the TV monitors. If a psuedo-color picture is desired, the digital image data is color encoded and applied to the color TV monitor for display.

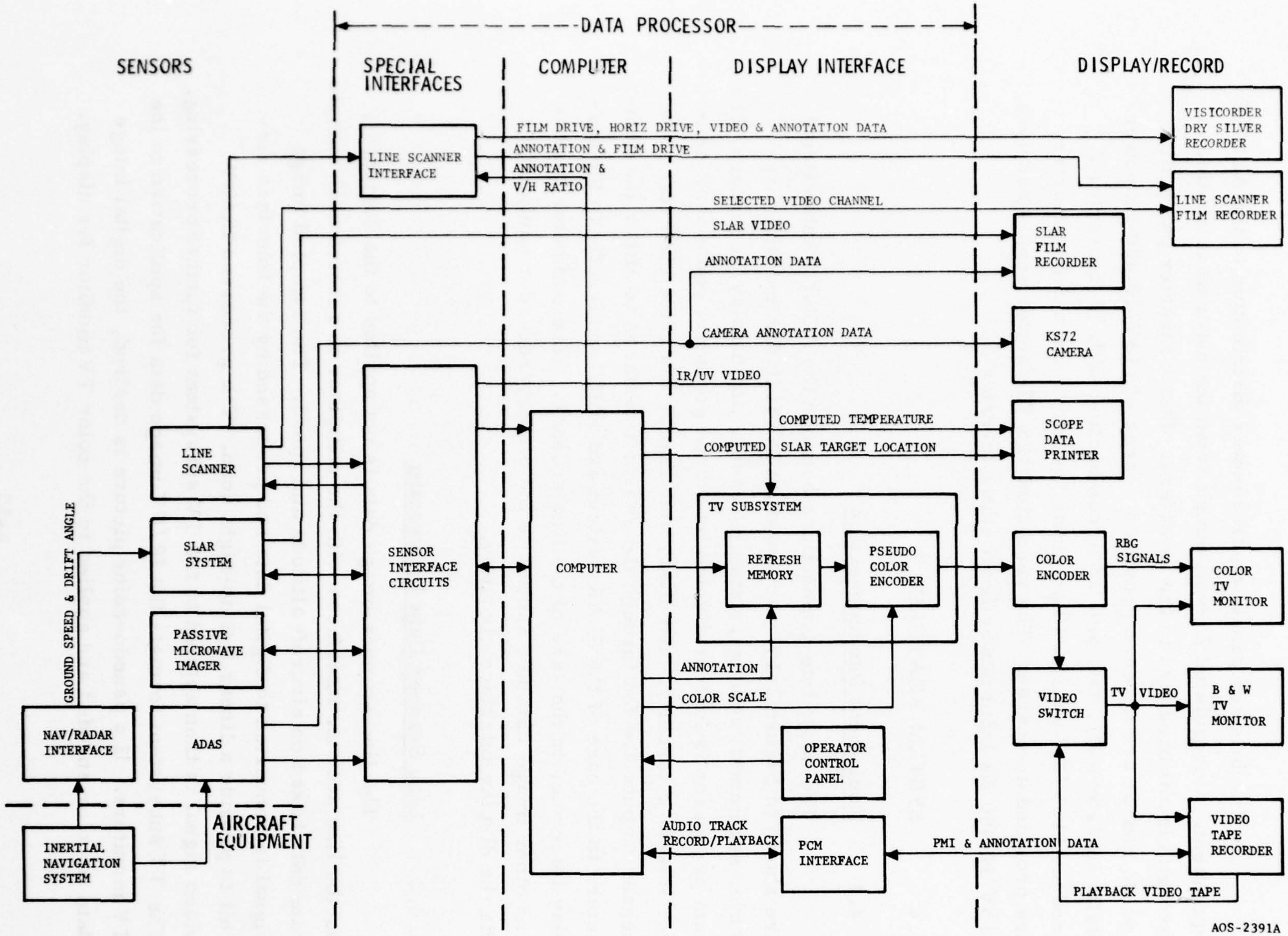


Figure 2-19. AOSS II Functional Flow Diagram

The UV and IR scanner image data is also continuously recorded by a separate film recorder and a visicorder oscillograph.

Line scanner calibrated hot and cold blackbody temperature signals are monitored by the computer for insertion on the line scanner film. A sample of the IR video signal is compared with the blackbody signals, and a computed temperature of the surface passing directly below the aircraft is obtained. The computer combines computed temperature with time, altitude, and position data for printout.

2.4.3 SLAR and PMI Data Processing

The SLAR and PMI image data are routed through their respective interfaces to the computer. The computer temporarily stores the data for yaw correction and then retrieves it and processes it to produce a linear rolling map display of the swath coverage of each sensor. The computer-processed SLAR and PMI data is TV-formatted and color-encoded by the TV subsystem for application to the color TV monitor and video tape recorder. The SLAR image data is continuously displayed and recorded on a separate film recorder. The PMI data is continuously recorded by the video tape recorder on one of the two audio tracks. The second track is used for voice recording of significant mission events.

An added feature of the processor display system is the determination of the longitude and latitude of SLAR targets of interest. Since the SLAR targets are located at right angles to the aircraft line of flight, the computer must compute target longitude and latitude from the aircraft position. The longitude and latitude of the SLAR target are displayed in the graphics annotation and are also printed by the offline printer. The SLAR target location data can be entered as way points in the aircraft inertial navigation system for purposes of over flying the target.

2.4.4 Inertial Navigation System Data

The inertial navigation system supplies aircraft ground speed, position, heading, pitch, roll, and yaw data. These signals are routed to the airborne data annotation system (ADAS) together with altitude data from an altimeter. The ADAS produces a time reference and formats the data received from the inertial navigation system and altimeter for application to the computer. The navigation/radar interface extracts ground speed and drift angle data from the inertial navigation system serial data and applies this information to the SLAR film recorder for control of film speed.

The sensors also receive signals from the computer via the sensor interfaces. These signals control sensor performance according to AOSS II operating parameters and aircraft flight parameters (speed, altitude, pitch, roll, and yaw).

2.4.5 Operator Control Panel

The operator control panel controls AOSS II operation. The control panel selects the sensor output to be displayed on the color TV monitor, whether the display will be in black-and-white or color, what data will be recorded, whether annotation data will be displayed, and the display configuration of the annotation data. The operator control panel also selects color scales, SLAR threshold alarm level, and performs several other operational selection, monitoring, and test functions.

2.4.6 Display/Record Circuits

The display/record circuits include a color encoder, color TV monitor, black-and-white TV monitor, video tape recorder, Scope Data printer, KS-72 camera, SLAR film recorder, line scanner film recorder, and a visicorder oscillograph. The display circuits provide a visual image of the selected sensor. The record circuits record the TV monitor display along with a record of operating parameters,

PMI video data, and voice annotation. The film recorders record the SLAR and line scanner images on film. The SLAR film recorder and visicorder oscillograph images are printed on a continuous film and are available for viewing at a slight time delay after exposure. The film in the line scanner film recorder and KS-72 camera must be removed and developed before the images are available for viewing.

The film recorders record the SLAR and line scanner outputs and are annotated with time and other pertinent information for later data reduction. The film in the SLAR film recorder moves at a speed determined by the SLAR range scale and aircraft ground speed. Thus, a valid aspect ratio of the recorded image is maintained for different range scales and aircraft speeds. The film in the line scanner film recorder and the visicorder oscillograph moves at a speed determined by aircraft speed divided by altitude. This also assures that the recorded image has a correct aspect ratio.

The offline printer is used to print SLAR target locations and L.S. water surface temperatures. One printed water temperature is included with aircraft longitude, latitude, altitude, time and heading. The printed water temperature is from directly below the aircraft line of flight.

The video tape recorder contains three tracks for recording three types of information. The video track records the image present on the TV monitor and one audio track records PMI data. The PMI data is recorded along with ADAS information. The ADAS information contains inertial navigation data concerning position, speed, altitude, time, yaw, pitch and roll. Thus, during playback of the audio track containing PMI data; graphics may be displayed, various color scales switched, and the image enhanced at the operators option. This option is not possible when playing back the video track where the playback image is the same as the recorded image. The second audio track is used for recording voice annotation. Voice annotation is useful during playback as an aid to data reduction and relating photographs and film recordings to the recorded TV image.

2.4.7 Equipment Characteristics

Table 2-1 compares the characteristics of the AOSS II sensors and lists their primary functions. Table 2-2 describes the AOSS II capabilities and limitations.

Table 2-1

SENSOR COMPARISON TABLE

SENSOR	PRIMARY FUNCTION	RESOLUTION	OPTIMUM ALTITUDE	SENSITIVITY	RECORDING MECHANISM	RANGE (N MI)
1. OSDR-94 SLAR	Ship detection Oil spill detection and mapping	Azimuth 95.6 ft/n mi Range 100 ft	7500 ft	-95 dbm	9" film Real time color display Video tape Ship threshold Alarm	26 (20x60 ship) 10 Oil (5 knot wind)
2. 37 GHz Imager	Spill detection and mapping	2.1° El x 3.3° Az	2000 ft	$0.9^{\circ}C\ \Delta T$ in a 20 msec integration period	Real time color display Video tape	Dependent upon altitude Beam angle offset 45° from vertical
3. Line Scanner	Spill mapping Oil type identification	2.5 mrad (2.5 ft at 1000 ft alt)	1000 ft	$0.12^{\circ}C$ (8-13 μm) $0.22^{\circ}C$ (8-9.5 μm) Twilight-UV	70 mm film Real time color display Video tape	N/A Downlooker $\pm 50^{\circ}$ swath
4. KS-72 Camera	Ship identification and validation of recorded data	Lens / FOV 3" / 73° 44' 6" / 41° 06' 12" / 21° 14'	Dependent upon weather	Daylight to twilight automatic exposure	Film: B&W or color, 4½x4½"	Dependent upon altitude, lens, and weather

Table 2-2

AOSS II CAPABILITIES AND LIMITATIONS

EQUIPMENT	PARAMETERS	CHARACTERISTICS
Detection		
SLAR	Freq:	X Band (tuneable)
	Peak Power:	45 kW min.
	Pulse Width:	0.2 ±0.025 μsec
	PRF:	750 ±10 pps
	Coverage:	Horizontal: 0.9^{o} between half-power points Vertical: Depressed 3^{o} to 45^{o}
	Range:	50 Kilometers (27 nm) 25 Kilometers (13.5 nm)
	Resolution:	30 meters (98 feet)
	Display:	Photo radar map and color TV monitor
	Target Location: (data processor computed value)	Printout of selected target computed longitude and latitude
Line Scanner	Spectrum: (3 channels)	UV - 0.32 to .38 μm (channel 3) IR - 8 to 13 μm (channel 1) 8 to 9.5 μm (channel 2
	Scan Coverage:	100^{o} across direction of flight, with $\pm15^{o}$ roll stabilization 2.5 mrad in direction of flight
	Scan Rate:	5,000 rpm 83.3 scans per second
	Detectors:	IR - Hg:Cd:Te UV - P-13 photomultiplier
	Display:	Photo map and color TV monitor
	Airborne remote temperature (Data Processor computed Value)	Printout of computed temperature with longitude latitude, altitude, heading and time.
PMI	Frequency	37 GHz
	Scan Coverage:	Forward 120^{o} across direction of flight in a 45^{o} cone axis. Scan radius equals aircraft altitude.
	Scan Rate:	Variable from 8 to 88 rpm as determined by aircraft V/H ratio

Table 2-2 (Continued)

AOSS II CAPABILITIES AND LIMITATIONS

EQUIPMENT	PARAMETERS	CHARACTERISTICS
Detection (cont)		
PMI	Display:	Color TV monitor, linear display corrected from circular scan and smoothed by data processor.
	Recording:	Magnetic tape recorded and/or video taped when displayed on TV monitor
Recording		
SLAR	Photo Map:	25 or 50 km to either or both sides of flight line
	Resolution:	30 lines/mm min.
	Film Width:	9-1/2 inches
	Recording time:	Varies with aircraft speed and radar range
Line Scanner Film Recorder	Photo Map:	Area 100° across direction of flight
	Resolution:	2.5 mrad at 40% MTF on film
	Film Width:	2.5 inches (nominal)
	Recording Time:	Varies with aircraft speed and altitude
Visicorder Oscillograph	Photo Map:	Area 100° across direction of flight
	Film/paper Width: Length:	6 inches 100 or 200 feet long
PMI	Magnetic Tape:	Audio track
	Recording Time:	1 hour per reel
	Area Recorded:	40° on either side of flight line
KS-72 Camera	Photo Coverage:	Area across line of flight or at 45° to port side of aircraft.
	Field of View:	3-inch lens: 73° 44' 6-inch lens: 41° 06' 12-inch lens: 21° 14'
	Frame rate:	6 frames/second max. Variable with aircraft speed and altitude
	Photo size:	4 1/2 x 4 1/2 inches
	Film capacity:	500 feet with standard cassettes

Table 2-2 (Continued)

AOSS II CAPABILITIES AND LIMITATIONS

EQUIPMENT	PARAMETERS	CHARACTERISTICS
KS-72 Camera (cont)	IMÇ accuracy:	From ±7% at 0.10 inch per second to ±2.0% at 12.0 inches per second.
	Exposure:	Automatic exposure control with compensation for installed lens and cloud coverage.
	Night Mode operation:	Pyrotechnic flare or strobe light illumination
		Shutter tripped by light from flare or strobe
Offline Printer	Paper Type:	Electroresistive
	Paper Dimensions:	8 1/2 inches wide, (approximately 300 feet long)
	Printing Format:	80 characters per line, 10 characters per inch, 6 lines per inch
	Printed Character Format:	7 x 9 dot matrix, 96 printable characters
	Printing Speed:	120 characters per second max.
		1 line per second in system operation

Section 3
AOSS MODIFICATIONS AND INSTALLATION

The two primary tasks of the program were to execute the operational improvements to the AOSS equipment (Task I) and install and flight test the system aboard the HC-130B aircraft (Task II). Figure 3-1 reflects the phasing and accomplishment of the program tasks and depicts the key program milestones.

Work on these tasks began 5 March 1976 upon notification of contract award. Modifications to the system equipment were completed 3 January 1977. The actual installation of the equipment began on 1 November 1976; however, the Task II effort began with the award of the subcontract to Lockheed Air Service Company for the aircraft modifications. Following completion of the installation of the modified AOSS equipment into the aircraft in late November, the aircraft and equipment were subjected to a series of engineering and acceptance tests to certify the airworthiness of the aircraft and to verify the performance of the AOSS II equipment. These efforts culminated with completion of acceptance and performance flight tests on 7 April 1977 and the delivery of the aircraft and system on 9 April 1977.

The following subsections describe the work performed to accomplish the AOSS equipment modifications and installation of the equipment into the aircraft. The two primary tasks are broken down by subtask to identify the objectives, approach, extent, and chronology of the equipment and aircraft modifications. Discussion of the flight test evaluation and the analysis of the flight test data is deferred to Section 4 of this report where it is treated in more detail.

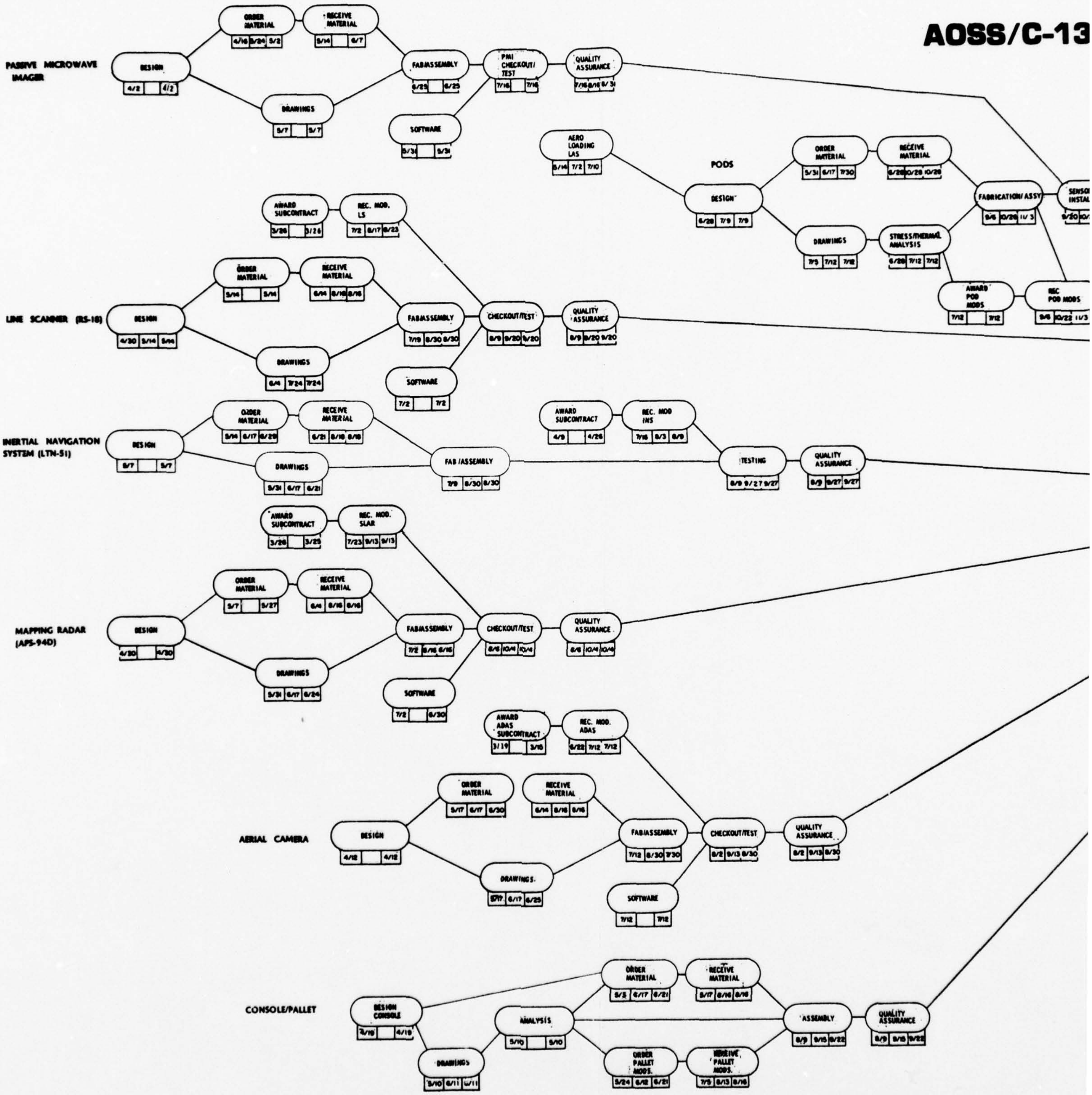
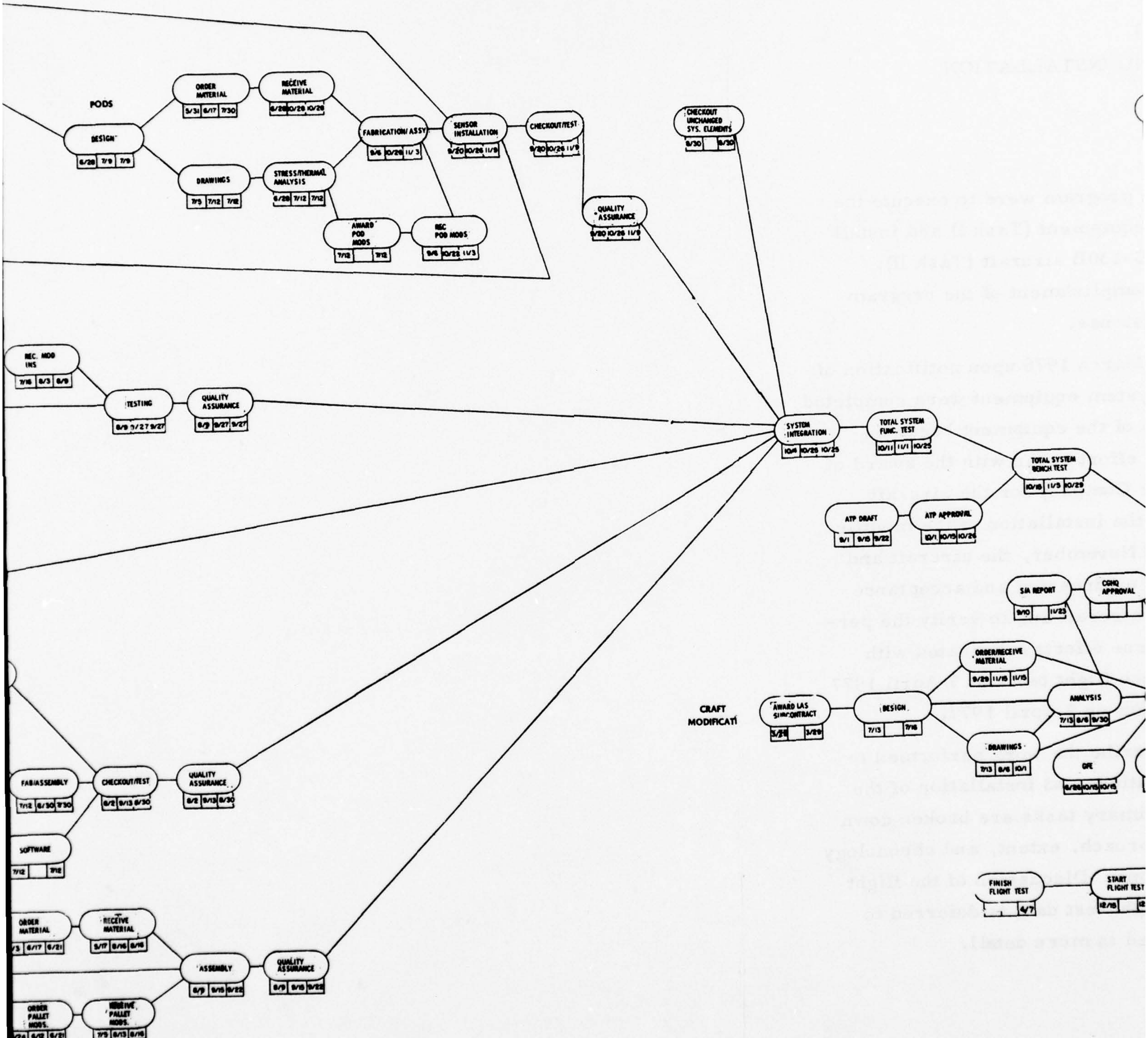


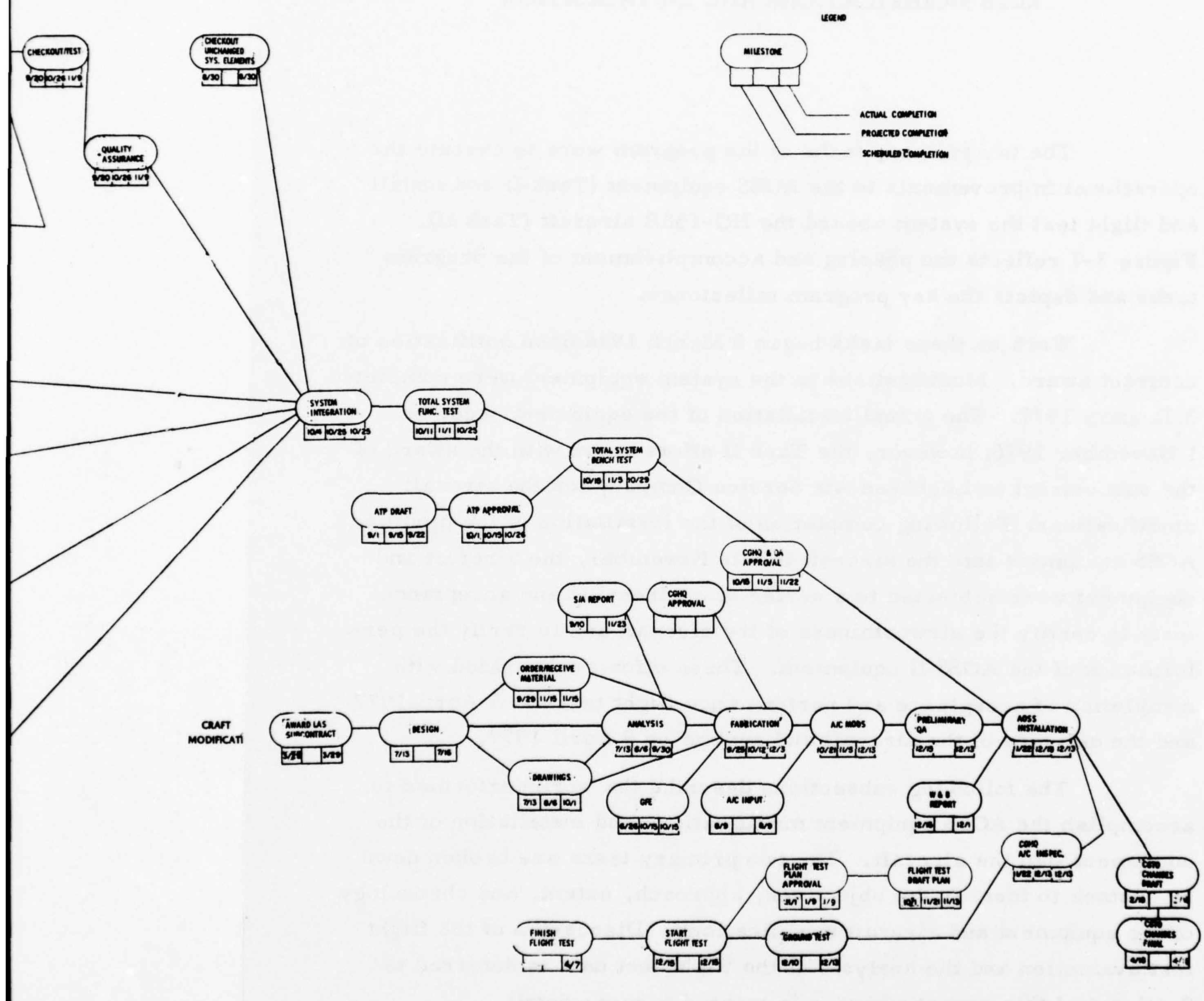
Figure 3-1. Program Schedule

AOSS/C-130 PROGRAM MILESTONES



2

PROGRAM MILESTONES



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3

3.1 AOSS MODIFICATIONS (TASK I)

Task I encompasses modifications to the AOSS sensors, addition of the KS-72 aerial reconnaissance camera, modifications to the inertial navigation system, installation of the consoles and associated equipment racks onto a standard HC-130B cargo pallet, pod installation, and system integration and bench checkout. Also included are software modifications that were incorporated to accommodate operational changes in the equipment or to enhance the data processing and display/recording functions.

3.1.1 PMI Modifications (Subtask Ia)

Two basic modifications were made to the PMI: (1) increase the maximum scan speed from 35 rpm to a minimum of 70 rpm with a design goal of 90 rpm (a maximum scan speed of 88 rpm was achieved) permitting operation at lower altitudes and/or higher ground speeds and (2) alter the software to allow smoothing in both the along-track and cross-track dimensions and to present a traveling color scale bar chart directly adjacent to the PMI data being displayed.

Increasing the scan speed of the PMI required a detailed design analysis to assure that the design capabilities of the drive torquer, amplifier, and support bearings would not be exceeded; PMI time constant wiring modification design and analysis; modification of the servo system to enable the higher rate of rotation; review of the PMI support structure and the mechanical support of all subsystem components to ensure their structural integrity under the increased loads imposed by the speed increase; and associated software changes to accommodate processing, display, and recording of the PMI data.

The design investigations resulted in the replacement of the support bearings and the slip ring assembly. Electronic components required for the increased scan speed were mounted on an additional printed circuit board and installed in a spare slot in the electronics section of the PMI.

Work on this task began 5 March 1976, immediately upon contract award, and concluded 16 July 1976 with the completion of the PMI checkout and testing.

3.1.2 SLAR Modifications (Subtask Ib)

Initially, three modifications to the SLAR were to be performed: (1) add a second antenna (sixteen-foot, horizontally polarized) to the SLAR to obtain increased azimuth resolution and a mapping capability on both sides of the aircraft; (2) restore the SLAR film recorder to its original configuration to allow recording and display of the left, right, or both antennas; and (3) provide a real-time target location readout. Under contract Modification No. 4, a fourth item was added to alter the manner of displaying the antenna video signals on the SLAR film recorder CRTs.

The first two items above and the contract modification were concerned with basically the same objective, that is, to enable simultaneous radar imaging of both sides of the aircraft flight path. To accomplish this objective, the existing AOSS 8-foot vertically polarized antenna and the 16-foot horizontally polarized antenna were used to provide right and left side viewing respectively. Dual-look antenna switching circuitry that had been disabled in the receiver-transmitter and OSDR radar processor for the AOSS I was restored for this modification. A reconfiguration of the digital integrator, the addition of an antenna selection switch readout input to the AOSS data processor, and a software modification to change the sense of the drift angle correction according to which antenna is active were accomplished to fulfill the objectives of the first item. With the exception of the software, these changes involved alterations to the antenna receive-transmit box, OSDR processor, and control box and were performed by Motorola under a subcontract to AESC. The software changes were performed by AESC.

The hardware changes to the radar data presentation and recording functions (Item 2 and Contract Modification No. 4) consisted of restoring the film recorder so as to record both antennas. In the present configuration, the SLAR film recorder displays the left antenna video full width on the left CRT and right antenna video full width on the right CRT when both antennas are in operation (BOTH mode). When only one antenna is in use, its video is displayed full width on its respective CRT. In addition, the gain level adjustment has been increased in range and is common to both CRTs. Software changes were made to permit reading the radar switch position (right, left, or both) so that the yaw correction logic corresponds to the mode selected, to change the graphics display to note the mode selected, and to change the yaw buffer control to display the corrected image for all modes.

The final modification to the software implements a real-time target location readout. A software cursor was created that is positioned by operator input through thumbwheels located on the operator control panel. The software modification incorporates computation of the latitude and longitude of each end point of each radar line displayed. By interpolation between end points, the location of the cursor (presumably, the cursor has been positioned on the desired target located on the display) is computed. Target locations are printed out by the offline printer and video display. The target location coordinates may then be inputted to the inertial navigation system as a waypoint permitting auto-navigation of the aircraft to the target location.

The SLAR modification task was initiated on 25 March 1976 with the issuance of the purchase order to Motorola for the radar and film recorder modifications. The software modifications were completed on 30 June 1976 and the rack modification, fabrication, and assembly on 16 August 1976. Checkout and test of the SLAR were concluded on 4 October 1976.

3.1.3 Line Scanner Modifications (Subtask Ic)

The line scanner has been modified to improve calibration accuracy, provide hard copy printout of absolute sea surface temperatures along the flight line, and simultaneously record the thermal IR and UV channels.

To improve the calibration accuracy, the blackbody calibration sources were replaced with two thermoelectric blackbody sources capable of being heated and cooled to a controlled temperature. This task was performed by Texas Instruments under a subcontract to AESC.

The airborne remote temperature (ART) modifications required the design and fabrication of an interface to digitize the blackbody and center-of-scan temperatures and subsequently route them to the AOSS II computer. Software additions were made to calculate temperatures of the sea surface from the IR and the blackbody calibration data. An offline printer was interfaced to the AOSS II computer, and printer routines were added to the software to print out temperature, latitude, longitude, and time.

A Honeywell visicorder was added to permit recording the IR and UV channels simultaneously. Buffer circuit cards were designed to interface the additional recorder, and the software annotation was altered to identify the L.S. channel being recorded.

The purchase order to Texas Instruments for the line scanner calibration system modifications was initiated on 26 March 1976, and the modified line scanner was returned to AESC on 23 August 1976. In the interim, design, parts procurement, and fabrication of the ART interface and the rack modifications were completed, and the offline printer and the additional recorder were purchased. The software modifications were also completed in this interval. Checkout and testing of the system were completed on 20 September 1976.

3.1.4 Navigation System Modifications (Subtask Id)

The LTN-51 inertial navigation system was modified to permit interchangeability of the AOSS II INS with other Coast Guard LTN-51 systems. Under Contract Modifications No. 6 and No. 8, additional changes to the INS were requested by the Coast Guard to provide for an interface between the INS and the aircraft flight director instruments.

To implement the interchangeability modifications, USCG Search Program No. 100545 was modified to provide the following outputs on the ARINC binary-coded-decimal (BCD) data bus: present-position latitude, present-position longitude, ground speed, true heading, and drift angle. These data are in BCD format and use labels and scaling identical to that of Computer Program 100540. In addition, further program modifications were performed to output ground speed and drift angle on the ARINC 561 binary bus. All other features of computer program 100545 remained unchanged.

A navigation/SLAR interface unit was designed and built by AESC to compute/output ground speed and drift angle errors from the SLAR to provide interchangeability with other USCG LTN-51 INSs. This interchangeability applied only to LTN-51s that have the modified USCG 100545 program (other USCG LTN-51 units must be reprogrammed for full fleet interchangeability).

In addition to the program changes described above, modifications to the autopilot controller, SMU, CDU and MSU wiring interfaces were required. Under subcontract to AESC, Litton Aero Products supplied a modified pallet system consisting of wiring changes and connectors to interface with the SMU, APC, CDU, MSU, power, and NAV/SLAR interface unit. In addition, all signals used in the USCG HC-130B application are present on the pallet output connectors.

The additional USCG-requested LTN-51 (INS) interfacing to the HC-130B aircraft flight director was designed, fabricated, and installed. Specifically it provides a pilot option for actuation of the following INS input signals to the aircraft flight director:

Horizontal Situation Indicator (HSI)

HSI warning
True heading
X-track
To/From
WPT alert

Attitude Indicator

Warning (Gyro fail)
Roll
Pitch

INS input enable switches, normal navigation (VOR/ILS and TACAN) HSI enable switches and WPT alert and HSI warning lights were installed on the pilot's instrument panel.

Work on this task was initiated on 25 March 1976 with the issuance of the purchase order to Litton Aero Products for the program modifications and provision of the modified mounting pallet. Litton delivery to AESC took place on 9 August 1976. Design, fabrication, and assembly of the navigation/SLAR interface unit were completed on 30 August 1976. This effort was completed with checkout and testing of the INS on 27 September 1976.

3.1.5 Aerial Reconnaissance Camera (Subtask Ie)

A KS-72 aerial reconnaissance camera was added to the sensor complement. Integration of the camera into AOSS II required design and fabrication of a camera control panel and modification of the ADAS to provide annotation data to the camera.

The camera control panel is mounted on the operator control panel directly adjacent to the line scanner controls. The panel contains a six-junction mode selector, trip rate controls, film overlap control switch, cloud coverage compensation switch, film footage counter, failure lights, operating lights, and lens selection switch. Additional circuitry behind the panel converts the aircraft-supplied V/H signal to a signal compatible with the KS-72 camera image motion compensation and framing functions and generates V/H controlled camera trip pulses.

The ADAS was modified to provide the SLAR data annotation block to the camera. The annotation data, in alphanumeric form, is supplied to the KS-72 CRT for exposure onto the edge of the film.

The design of the control panel was initiated shortly after contract award. Fabrication, assembly and checkout of the panel were completed on 30 July 1976. A subcontract for the ADAS modifications was awarded to Fairchild on 15 March 1976. The modification to the equipment rack required to locate the camera control panel was completed in mid-August. Checkout and test of the camera subsystems was completed on 30 August 1976.

3.1.6 Pod Installation (Subtask If)

Unlike the prototype AOSS installation in the HU-16 aircraft in which the PMI and line scanner were fuselage-mounted, AOSS II mounts the two sensors in separate wing-mounted pods that are suspended from HC-130B underside wing pylons. The design and analysis for the pod modifications were performed by AESC. Aerodynamic loading and structural analyses were based upon worst-case loading data supplied by Lockheed Air Service.

The wing pods are 450-gallon wing tanks that have been extensively modified. The center sections of each pod were completely redesigned and fabricated. Following is a list of redesigned pod features.

a. Bomb rack type mounting lugs: Redesigned using full pod diameter "I" beam rings with bosses welded on to be compatible with the aircraft fuel tank pylons' mounting points.

b. Center section skin with longitudinal bolted joint: Redesigned using a stiffened skin (hoop and longitudinal stiffeners) with access to sensors, and appropriate windows for each of the two sensors.

c. Ogival nose and conical tail sections: Bulkheads were installed in each with bleed and ram air for environmental temperature control in the nose cone.

Additional modifications include mounts for the sensors and a feed-through connector panel for the sensor interfacing cables.

The lower-half center sections of each pod are unique because of the different scanning mechanization of the two sensors. The pod for the PMI sensor has a cylindrical section with its axis at 90 degrees to the axis of the tank. This cylindrical section forms a fairing around the sensor and houses the radome. The line scanner pod has a rectangular window 4.0 inches long and 12.0 inches around the circumference of the lower-half directly below the sensor. A weathertight retractable door seals the line scanner window when the sensor is not in operation.

Design of the pod modifications began on 30 March 1976. Pod layout; load, structural, and thermal analysis; and enclosure design were completed for both pods by the end of June 1976. Pod modification began in mid-July 1976 and was completed 3 November 1976. Installation of the sensors into the pods was completed on 9 November 1976.

3.1.7 Pallet Modification (Subtask Ig)

The combined console and associated equipment racks of AOSS II were mounted on a standard cargo pallet for installation within the cargo compartment of the HC-130B aircraft. In conjunction with the pallet modifications, the aircraft ICS system was expanded to

include a station on the AOSS II power supply rack. Under added scope provisions of Contract Modification No. 2, the HC-130B forward looking radar indicator and control panel were installed into the AOSS II data processor control rack.

The AOSS II console/equipment pallet is a standard U.S. Coast Guard furnished cargo pallet, modified for installation of the AOSS II consoles and ancillary equipment. The pallet is located at the forward end of the aircraft cargo compartment on a dual rail cargo handling system. Modifications to the pallet panels consisted of designing inserts to distribute the various loads from the consoles into the pallet panels. The radar electronics and console, the power supply rack, the computer enclosure rack, the data processor console and an operator's seat were mounted to the pallet.

Installation of the forward looking radar indicator and control panel required both internal rework and equipment relocation on the data processor console. The line scanner power supply was moved from the top left side of the console to the top right side of the console above the color TV monitor. A new TV monitor support structure was designed and fabricated. Cables were rerouted so as not to effect RFI integrity. The tape recorder was moved to the uppermost position on the right side of the console. The radar indicator scope and control panel were mounted on the right side of the console at operator eye level. The indicator scope is hard-mounted within the console. New internal support structure was designed and fabricated to accommodate this arrangement. A new front panel was also designed and fabricated to serve as the control panel support while preserving the RFI integrity of the console. New cables were fabricated for installation within the console and for routing from the console to the aircraft AOSS II distribution panel.

The design and layout of the pallet modifications began at the inception of the contract and were completed 19 April 1976. A structural analysis was performed to verify load factors and margins

of safety. The analysis was completed on 10 May 1976. Basic pallet modification was completed on 16 August 1976. Total pallet assembly was completed on 22 September 1976.

3.1.8 System Integration and Bench Checkout (Subtask Ih)

As the final step in Task I prior to installation of the system into the HC-130B aircraft, AOSS II integration and acceptance testing was performed. First, the modified subsystems were checked out along with their associated software modifications. The complete integrated system was then tested against simulated targets in the laboratory. Formal acceptance tests using a USCG approved acceptance test procedure developed under this task were conducted to verify system operation and within tolerance performance of the equipment, sensors, and software.

System integration and checkout was completed on 25 October 1976. Total system acceptance tests were completed on 29 October 1976 and were formally approved by the Coast Guard on 22 November 1976.

3.2 INSTALLATION OF THE AOSS EQUIPMENT INTO THE HC-130B AIRCRAFT (Task II)

Under a subcontract from AESC, Lockheed Aircraft Service Company (LAS) of Ontario, California, provided the facilities, materials, personnel and equipment necessary to design, fabricate, modify, and install the AOSS II components described in the following paragraphs. The modifications and installation tasks were accomplished at the LAS facility at Ontario, California. This effort encompassed ten program subtasks itemized below:

Subtask IIb	OSDR Radar Surveillance System Installation
Subtask IIc	AOSS II Instrumentation Pallet Installation
Subtask IId	Pylon Modification and Pod and Camera Installation

Subtask IIe	Retractable Landing Light Assembly Relocation
Subtask IIf	Wing Wiring to the Equipment Pods
Subtask IIg	Circuit Breaker Installation
Subtask IIh	Electrical Power and Cabling Installation
Subtask IIi	Inertial Navigation System Installation
Subtask IIk	Weight and Balance
Subtask IIl	Stress Analysis

3.2.1 Radar Surveillance System Installation (Subtask IIb)

The radar surveillance system installation consisted of two efforts: antenna installation and receiver-transmitter installation. Two antennas were installed for use with the OSDR radar system. An eight-foot vertically polarized antenna was installed on the right-hand wheel well fairing and a sixteen-foot horizontally polarized antenna was installed on the left wheel well fairing. Support structure for each antenna were designed to withstand the accelerations and loads imposed throughout the aircraft flight regime. Structure attachment fittings are provided at the wheel well skin, and the internal structure has been reinforced for antenna installation. Waveguide was routed from the aft ends of the antennas to the receiver-transmitter unit.

The receiver-transmitter was installed in the center overhead lighting trough. Structural support was added to interface with four vibration isolators and to provide a sway-space envelope for maintenance and inspection. Added support structure was designed and existing structure was strengthened to withstand linear and angular accelerations and all required cabling was installed between the receiver-transmitter and AOSS II distribution panel.

3.2.2 AOSS II Instrumentation Pallet Installation (Subtask IIc)

The system console, power supply, radar and computer racks were mounted on a standard C-130 cargo pallet. The pallet is located at the forward end of the cargo compartment on a dual rail

cargo handling system. All pallet-mounted equipment is designed and installed to withstand loads imposed at the mountings. Connectors for all pallet-mounted systems are located along the right-hand sidewall to permit installation/removal of the console pallet.

3.2.3 Pylon Modification and Pod and Camera Installation (Subtask IId)

Two wing pylons were modified and used for the installation of the AOSS II equipment pods. The pylon modification provides the structural attach points and support for the pods.

The pylon-to-wing attachment interface uses existing front and rear spar fittings. The mounting method is identical with the method employed for HC-130B model aircraft pylons, and each pylon is provided with a source of hot air from the aircraft bleed air system.

The KS-72 camera has been installed in the aft cargo door. The camera is mounted between the cargo door ribs and protrudes through the skin into an external enclosure. Two ports are provided in the enclosure, one for nadir viewing and the other for viewing at a 45-degree angle to the left of nadir. The camera mounting structure is designed to allow changing camera viewing angle while in flight, and use of 3-, 6-, or 12-inch focal length lenses. Inflight access to the camera and film magazine has been provided.

3.2.4 Retractable Landing Light Assembly Relocation (Subtask IIe)

As a result of the pylon/pod installation, the existing retractable landing light assemblies were relocated to a new position conforming to current Coast Guard pod-carrying C-130 E/H model configurations. The skin opening created by the light removal was flush-patched.

3.2.5 Wing Wiring to Equipment Pods (Subtask IIf)

The wiring required for the equipment pods was routed through the leading edge wing assemblies. Selection of this location was based upon the accessibility and maintenance requirements and was further influenced by the need to preclude electromagnetic interference effects. The pressure shell at the root end of the wing incorporates pressure-type bulkhead connectors.

3.2.6 Circuit Breakers (Subtask IIg)

Circuit breakers with nameplate identifications were installed to provide nonessential electrical power from the ac and dc circuit breaker panels in the cockpit.

3.2.7 Electrical Power and Cabling Installation (Subtask IIh)

An aircraft/AOSS II interface power panel was designed, fabricated, and installed on the right-hand sidewall of the forward fuselage. Cabling from the nonessential 28-Vdc buss terminates at the aircraft/AOSS II interface power panel with connectors.

An AOSS II distribution/interconnect panel was also designed, fabricated, and installed on the right-hand sidewall of the forward fuselage. All of the AOSS II sensor cabling from throughout the aircraft terminates with connectors at the AOSS II distribution/interconnect panel.

3.2.8 Inertial Navigation System Installation (Subtask IIi)

The AOSS II INS pallet is located within the forward cargo compartment area. The aircraft LORAN-A shelf was used to mount the INS pallet.

3.2.9 Weight and Balance (Subtask IIk)

After completion of aircraft modification and installation of the total AOSS II equipment, a weight and balance procedure was

performed on the aircraft. Chart A of Form DD365A was revised and updated to list AOSS II equipment items and their corresponding weights, arm, and moment.

3.2.10 Stress Analysis (Subtask III)

A stress analysis was performed to verify structural adequacy for the AOSS II equipment installations. The results of the analysis confirmed the adequacy of the design to withstand the structural loads imposed by the aircraft flight envelope. Further substantiation of the AOSS II installation was obtained from Edwards Air Force Base through a series of ground vibration testing and inflight observations taken during aircraft flight tests.

3.2.11 Ground and Flight Tests and Checkout (Subtask IIj)

Subtask IIj of the AOSS II program encompassed performance of post installation ground checkout, inflight shakedown and performance evaluation flight testing of the modified AOSS. Basic ground checkout was initiated after aircraft installation on 1 December 1976. Aircraft power was applied to each AOSS II subsystem, one subsystem at a time, until the entire system was under power. Detailed testing was subsequently performed, malfunctions were noted and corrective adjustments were made. This effort was completed on 15 December 1976. Flight testing was initiated on 15 December 1976 and completed on 7 April 1977. The flight tests led to AOSS II buyoff and are discussed in detail in Section 4, Flight Evaluation, of this report.

3.2.12 Data Requirements (Subtask IIm)

This subtask provided deliverable drawing and manual documentation reflecting all modifications performed to AOSS II and the HC-HC-130B aircraft as a result of this program.

Section 4

AOSS II FLIGHT EVALUATION

4.1 SUMMARY

The HC-130B Airborne Oil Surveillance System (AOSS II) flight test program included a series of data collection flights over coastal waters off Southern California during the period from December 1976 through April 1977. Figure 4-1 gives a generalized schedule of aircraft activities during this time frame. Fifteen data flights were conducted using 59.8 hours of flight time. The flights, summarized in Table 4-1, were conducted from Ontario International Airport, Ontario, California.

Table 4-2 summarizes the general objectives of the flight test program. The first objective was verification of the mechanical integrity of the AOSS II installation (Section 4.2). The second objective was to electrically shakedown and check out the AOSS II hardware to verify inflight functional operation (Section 4.3). The third and final objective was to obtain a series of data sets to substantiate/evaluate performance characteristics of each of the AOSS modifications (Section 4.4).

Table 4-3 summarizes the flight test objectives and desired targets as a function of individual AOSS II sensors that were evaluated after completion of the mechanical checkout phase of the flight test program.

4.2 INFLIGHT MECHANICAL CHECKOUT

The first objective of the flight test program was to obtain verification of the AOSS II installation from a flight safety standpoint. This was accomplished by the U. S. Air Force who conducted a series of ground and inflight tests at Edwards Air Force Base from 13 through 15 December 1976.

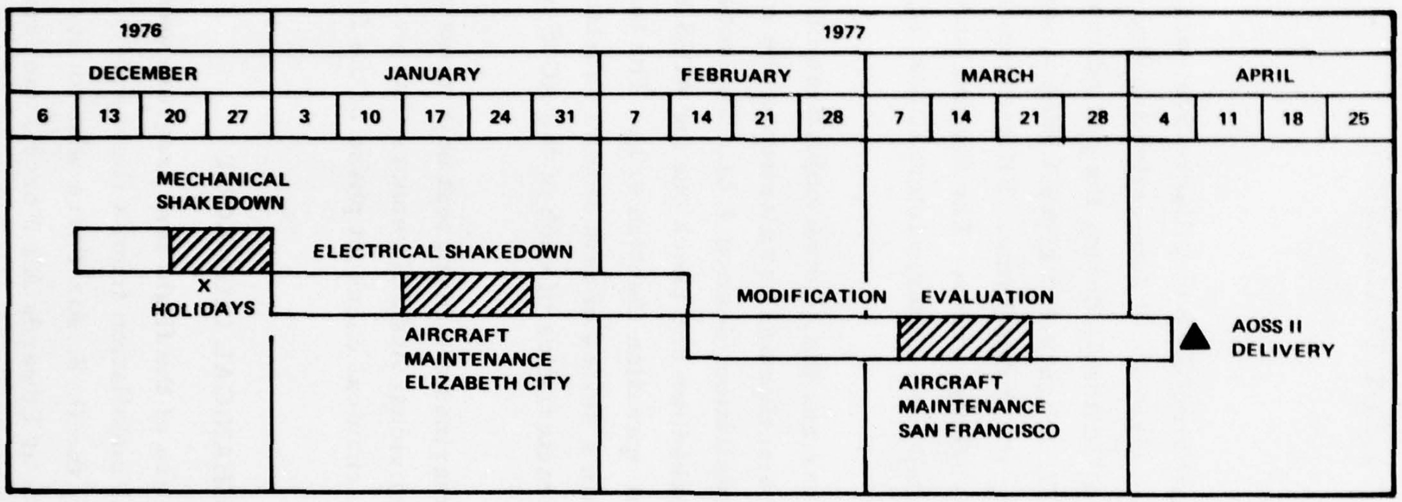


Figure 4-1. AOSS II Flight Test Schedule

Table 4-1

AOSS II FLIGHT LOG

Date	Flight No. (Mission No.)	Site	Flight Hours
12-15-76	1 (-)	Edwards AFB	2.6
1-11-77	2 (001)	Catalina Channel	3.1
1-12-77	3 (002)	Catalina Channel	2.4
2-15-77	4 (003)	Catalina/Santa Barbara Channel	4.3
2-21-77	5 (004)	Santa Barbara Channel	5.8
2-26-77	6 (005)	Santa Barbara Channel	3.7
3-1-77	7 (006)	Santa Barbara Channel	3.4
3-3-77	8 (007)	Santa Barbara Channel	5.8
3-8-77	9 (008)	Santa Barbara Channel	4.6
3-26-77	10 (009)	San Francisco to Santa Barbara	3.4
3-29-77	11 (010)	Santa Barbara Channel	2.4
3-30-77	12 (011)	Santa Barbara Channel	4.9
4-1-77	13 (012)	Fort Huachuca	4.8
4-5-77	14 (013)	Santa Barbara Channel	4.9
4-7-77	15 (014)	Santa Barbara Channel	3.7
		Total Flight Hours	59.8

Table 4-2

AOSS II FLIGHT TEST OBJECTIVES

Objective	Test Site	Duration	Aircraft Hours	Support Vessel	Support Aircraft Hours
Mechanical Checkout	Ontario/ Edwards AFB	2 weeks	2.6	N/S	N/S
Electrical Checkout	Catalina/ Santa Barbara Channels	6 weeks	10	N/S	N/S
AOSS II Modification Evaluation	Santa Barbara Channels	8 weeks	47.2	2 days	15

N/S - Not Scheduled

Table 4-3

INDIVIDUAL AOSS II SENSOR FLIGHT TEST OBJECTIVES

	Electrical Checkout Flights	Modification Verification Flights	Desired Targets
PMI	• Functional Operation • Brightness temperature verification • Color scale selection	• Increased scan rate verification • Image smoothing evaluation	• Islands/lakes • Smooth water of known temperature • Oil
SLAR	• Functional operation • STC setup	• Target position verification • Left/right display verification • Oil detection with horizontally polarized antenna	• Vessels • Oil • Offshore towers • Islands
Line Scanner	• Functional operation	• Functional ART verification • Simultaneous IR/UV recording verification	• Water of known temperature/position • Islands
KS-72 Camera	• Functional operation	• Functional ELT verification	• Vessels of variable size/markings • Islands

4.3 INFLIGHT ELECTRICAL CHECKOUT AND SHAKEDOWN

The second objective of the flight test program was to check out the AOSS II hardware and verify inflight operation. Three flights were conducted in the Catalina and Santa Barbara channels (Figure 4-2 generally shows flight lines used during the flight test program) for this purpose.

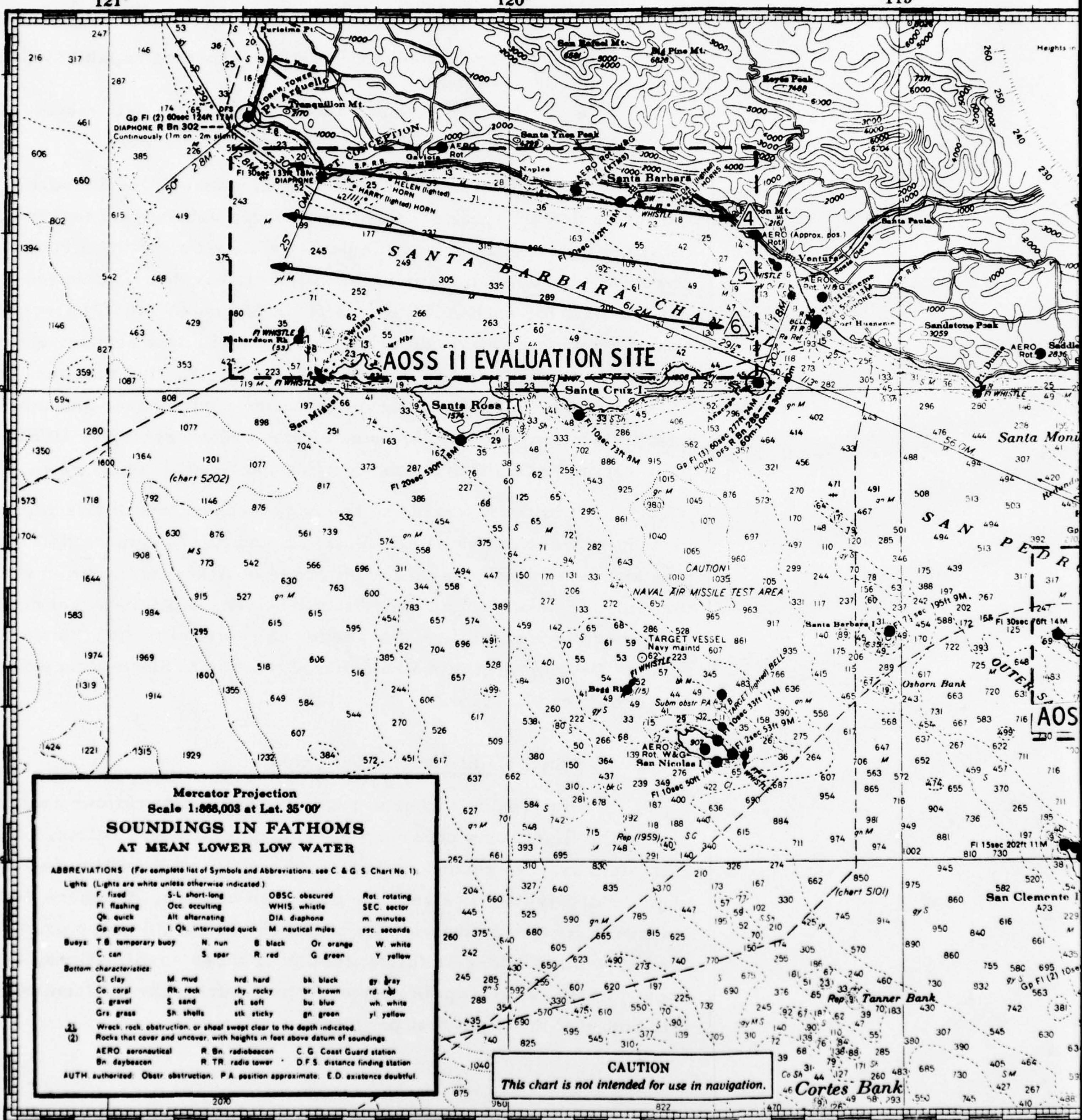
During this phase of the test program, total emphasis was on (1) inflight checkout of the systems, (2) equipment adjustments/alignments appropriate to system operation over water areas, and (3) data collection associated with instrument settings and software.

4.4 MODIFICATION EVALUATION

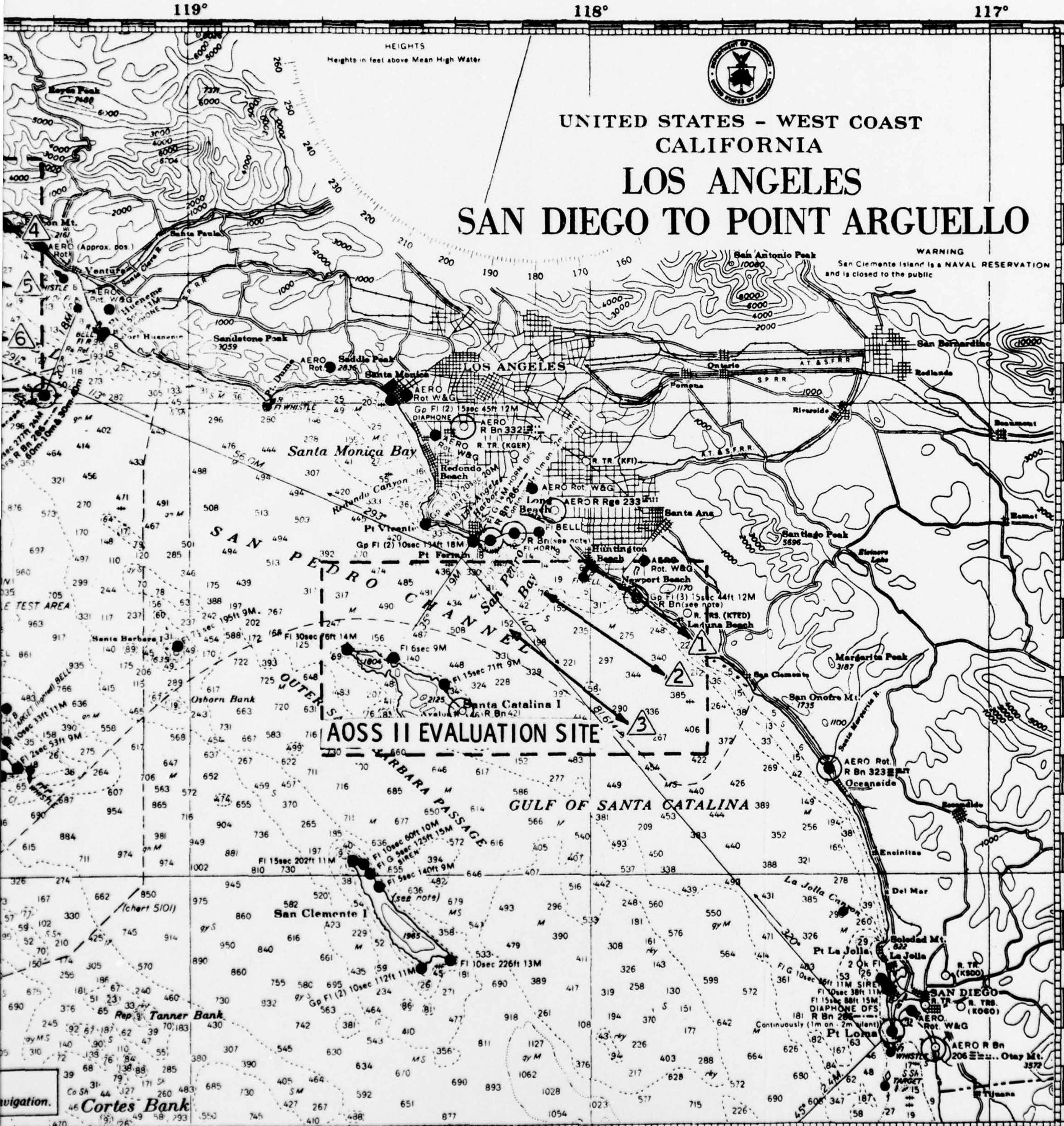
4.4.1 General

The objective for this portion of the flight test program was to obtain data sets to evaluate/verify the AOSS modifications as a function of inflight operational conditions. A series of nine data flights over a seven-week time interval were conducted over the Santa Barbara Channel coastal area for this purpose. Data were obtained to substantiate each of the AOSS II modifications by conducting repetitive flights over specified man-made and natural targets for a range of sensor and prevailing environmental conditions. The following AOSS II modifications represent the added system capabilities evaluated during this phase of the flight test program.

- Target cursor/location (SLAR)
- Left/right-display/film recorder operation (SLAR)
- Oil pollution detection with horizontally polarized antenna (SLAR)
- Airborne remote temperature (line scanner)



FLIGHT TRACK



ACK

Figure 4-2. Flight Test Locations

2

- Simultaneous UV and IR recording capability (line scanner)
- Increased scan rate and improved data display (PMI)
- Flight resolution ELT (KS-72 camera).

AOSS II data collection was augmented by the University of California Santa Barbara (UCSB) who, under subcontract to AESC, collected in situ sea surface temperature data during the airborne remote temperature missions. UCSB also provided (1) detailed weather data for each AOSS II data flight (Appendix B), (2) a verification of geometric image integrity for the SLAR, line scanner and KS-72 camera, and (3) an analysis of selected SLAR, line scanner, and KS-72 imagery in terms of target detection performance and target interpretability. Results of these efforts are presented by UCSB in their report "AOSS II Systems Verification Test" (Kraus, et al, 1977).

It is the intent of the following subsections of this report to provide representative SLAR, PMI, LS and KS-72 camera data examples and related discussion for purposes of AOSS modification evaluation only. For a detailed discussion/analyses of AOSS target detection phenomenology/capability, the reader is referred to AESC's final report "Development of a Prototype Airborne Oil Surveillance System" (Edgerton, et al, 1975).

4.4.2 SLAR Modification Evaluation

Sidelooking airborne radar (SLAR) modifications evaluated during the flight tests consisted of (1) target cursor/location, (2) left/right display/film recorder operation, and (3) oil detection capability of the added 16-foot horizontally polarized antenna. Offshore drilling platforms located in the vicinity of known natural oil seeps provided readily available targets for evaluation of these modifications, and consequently, were repetitively overflown during the performance of this phase of the flight test program.

4.4.2.1 SLAR Target Cursor/Location

The SLAR target cursor/location modification allows the AOSS II operator to position a software cursor on SLAR targets displayed on the TV monitors, and to subsequently obtain a target location readout in the form of latitude and longitude coordinates. Computation of the SLAR target location is accomplished by computing the latitude and longitude of each end of each SLAR data line as the line is presented on the display. These positions are saved in the computer memory and used to interpolate target position whenever the target cursor is activated and position is requested.

To locate a target the operator activates a sense switch on the system control panel causing a three-sided cursor to appear in the center of the TV screen. The cursor can then be moved to the desired target by inputting to the computer x and y coordinates specified by display line number (1-512) in the y-axis and picture element (1-400) in the x-axis. When the cursor is centered upon the target the operator presses the display button on the operator's control panel and obtains target latitude and longitude coordinates. These coordinates are displayed on the bottom line of the TV graphics and are simultaneously printed along with time on the offline printer.

Figure 4-3 shows a SLAR image of Coal Oil Point and offshore drilling Platform Holly, without activation of the target cursor. Figures 4-4 and 4-5 show Platform Holly being cursored while being imaged with the horizontally and vertically polarized antennas, respectively. These images were obtained within a one-hour time interval with the SLAR operating in the both antenna display mode at a 0-25 km range setting. In Figures 4-4 and 4-5 Platform Holly's position has been computed and is displayed in the bottom line of the annotation graphics. The following compares these positions with the actual position of the platform.

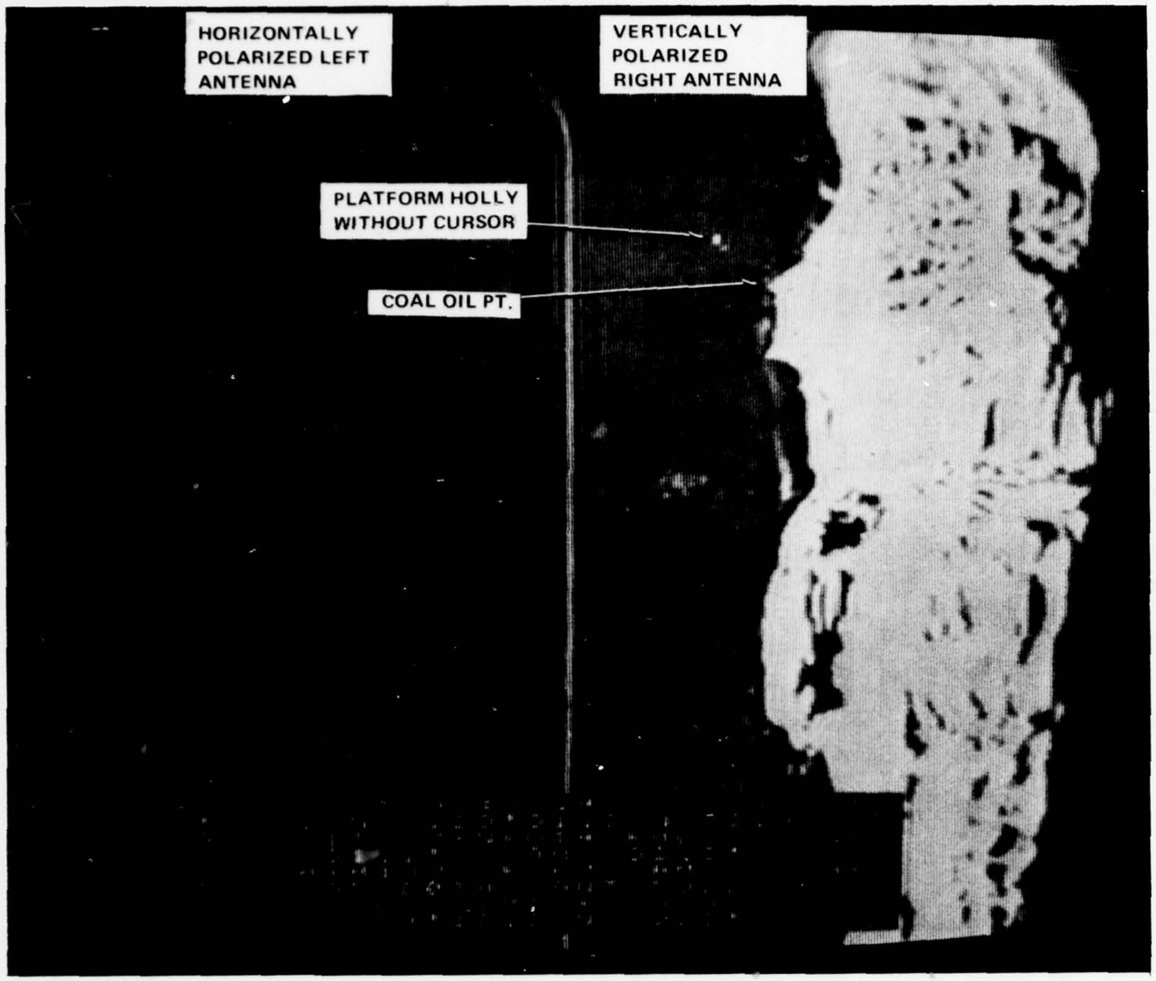


Figure 4-3. AOSS II SLAR Image Showing Platform Holly without Target Cursor

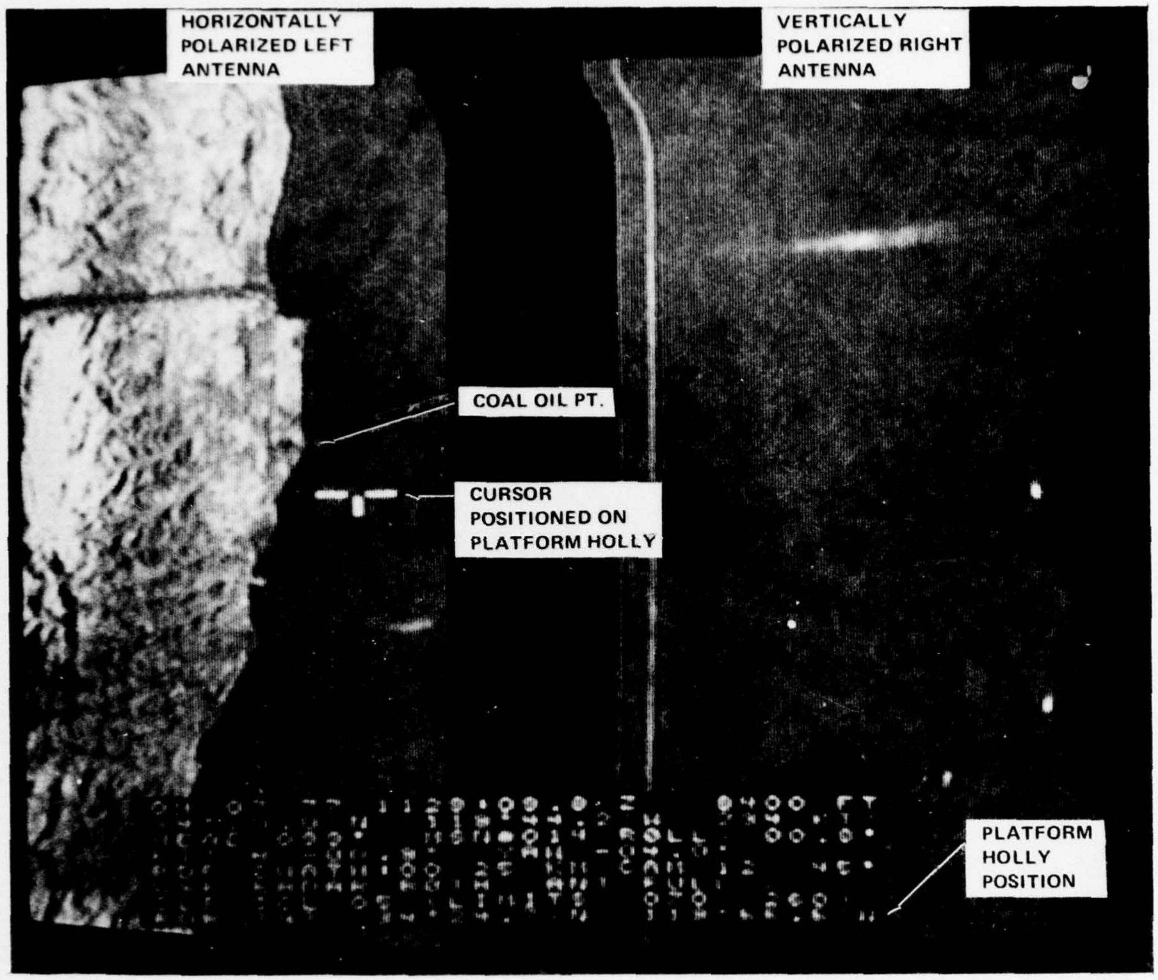


Figure 4-4. AOSS II SLAR Image Showing Platform Holly with Cursor While Being Displayed by the Horizontally Polarized Left Antenna

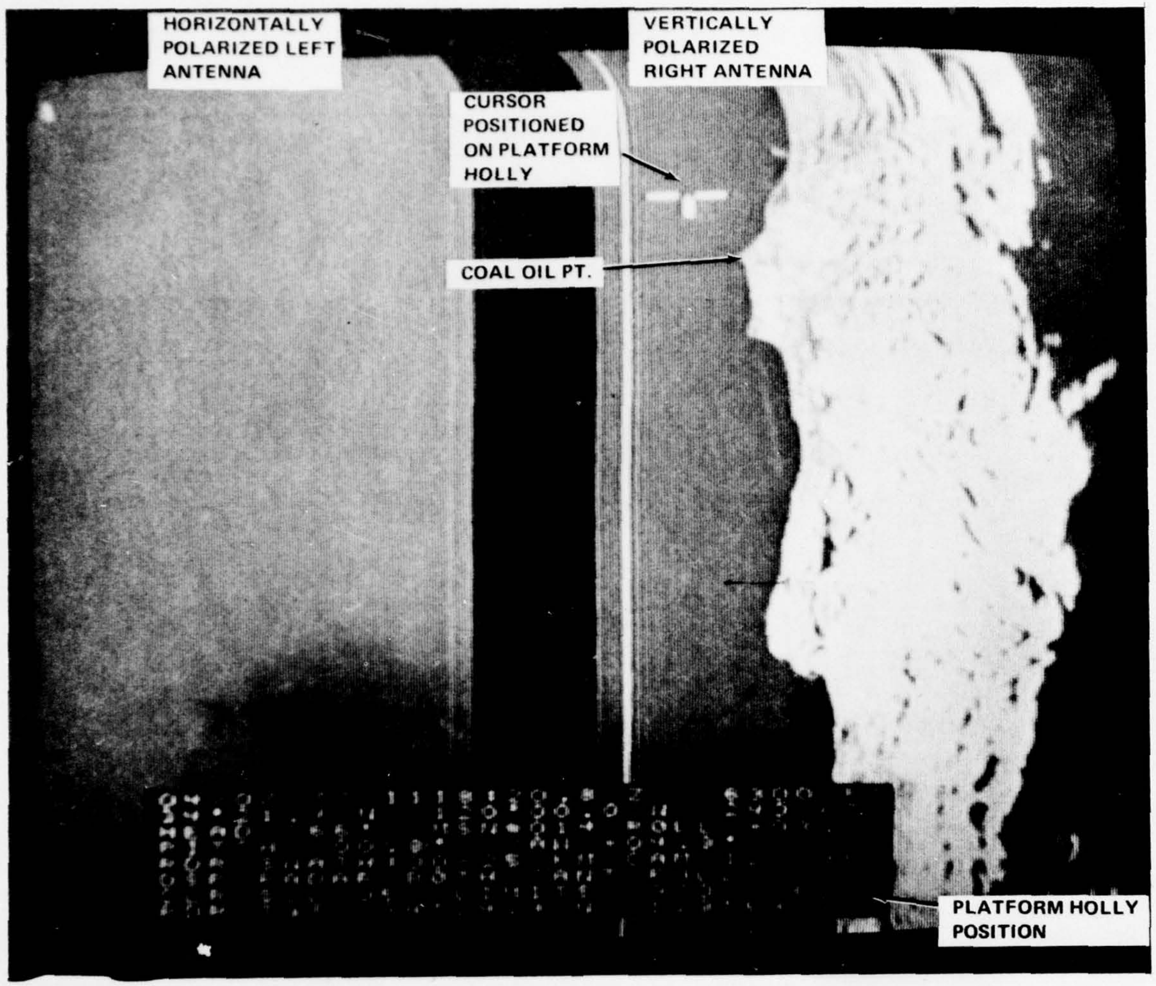


Figure 4-5. AOSS II SLAR Image Showing Platform Holly with Cursor While Being Displayed by the Vertically Polarized Right Antenna

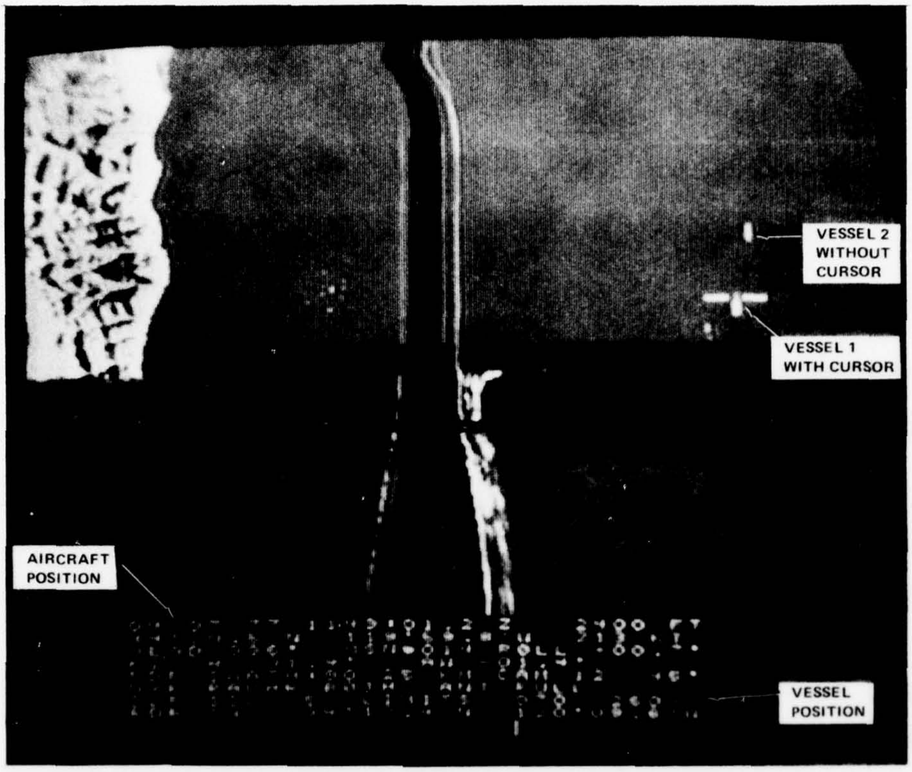
Figure	Aircraft Heading	Latitude	Longitude
4-4 (computed position)	92°	$34^{\circ}24.7'$N	$119^{\circ}55.5'$W
4-5 (computed position)	275°	$34^{\circ}24.4'$N	$119^{\circ}54.9'$W
Actual Position	-	$34^{\circ}23.3'$N	$119^{\circ}54.3'$W

The maximum discrepancy between the computed positions and actual position of the platform is 1.4 minutes in latitude and 1.2 minutes in longitude. This discrepancy is attributed to a combination of (1) the accuracy of the LTN-51 INS (1.36 nautical miles/hour), and (2) possible error induced by the system operator when positioning the cursor on the target.

Figure 4-6 shows radar images of two vessels being cursored within a time interval of less than one minute. These vessels were detected immediately after an aircraft course change (hence, the dark horizontal bar across each image). Both vessels were large freighters that could be considered as suspect violators during the long range detection phase of a MEP flight mission. If either of these vessels had been spilling oil, it would have been a simple matter to autonavigate the aircraft by use of known aircraft and target positions (given below) over the suspect vessel(s) for purpose of short range inspection/identification AOSS II overflights.

Vessel 1		Vessel 2	
Aircraft Position	Target Position	Aircraft Position	Target Position
$34^{\circ}20.5'$N	$34^{\circ}12.4'$N	$34^{\circ}20.3'$N	$34^{\circ}12.0'$N
$119^{\circ}59.8'$W	$120^{\circ}09.6'$W	$119^{\circ}57.5'$W	$120^{\circ}08.0'$W

During the entire flight test program the target cursor consistently positionted targets within the accuracy of the INS, and should prove itself to be a valuable tool to the Coast Guard's MEP, ELT and SAR missions during all weather conditions.



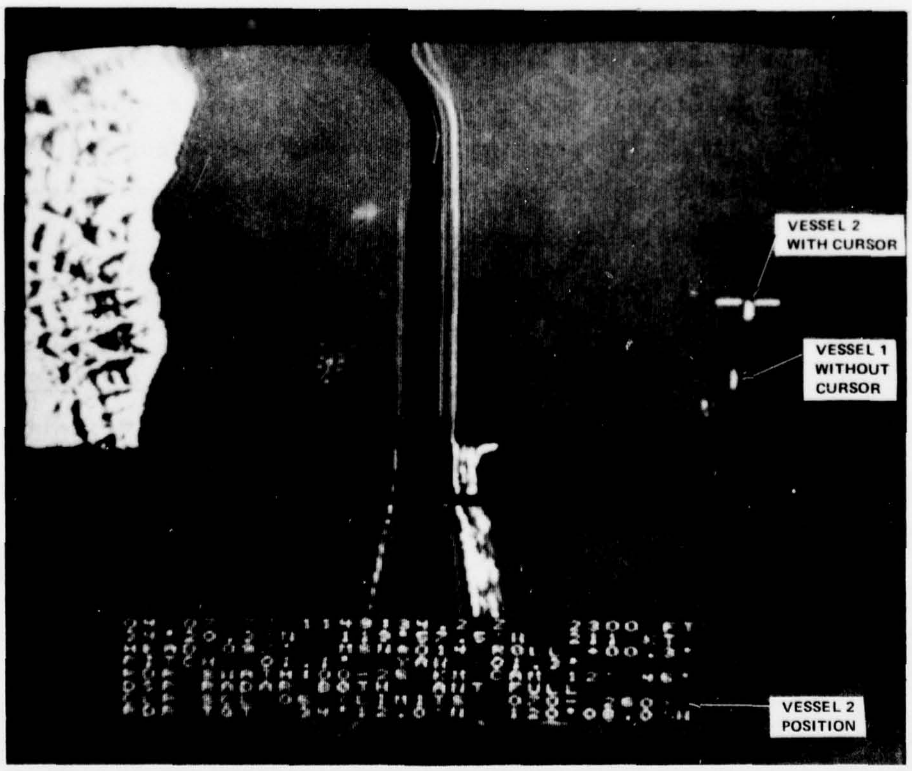


Figure 4-6. AOSS II SLAR Imagery Showing Two Freighters Being Cursored

4.4.2.2 Left/Right Display/Film Recorder Operation

Figures 4-7 through 4-12 are SLAR images obtained from both the TV display and the SLAR film recorder. They represent SLAR data obtained while imaging the Santa Barbara coastline in the right only, left only, and both antenna look modes. These figures verify the capability of the AOSS II system to display these antenna modes of operation, both on the TV display and the SLAR film recorder. The dark area in the center of the TV displayed imagery represents the $\pm 45^{\circ}$ SLAR "blind" area directly beneath the aircraft.

4.4.2.3 Oil Pollution Detection with Horizontally Polarized Antenna

The ability of a SLAR to detect and map oil slicks results from oil film suppression of natural radar backscatter from the ocean surface. An oil slick reduces the fine wave structure (which represents a substantial percentage of the radar backscatter) significantly reducing the effective radar cross section of the surface. Hence, an oil spill appears as a dark, well-defined area of nonscattering which is bounded by the contrasting lighter return from the unsmoothed sea on a typical radar image (Edgerton, et al, 1975). Also, theory and measured data indicate that a vertically polarized SLAR will provide a stronger ocean backscatter return than a horizontally polarized SLAR during sea states equal to or less than three, and therefore will provide a better oil spill detection and mapping capability during periods of low wind and calm seas (Aerojet ElectroSystems Company, 1975). It was these considerations that led to the configuration and subsequent integration of a vertically polarized SLAR antenna (OSDR-94) into the original AOSS. The ability of the vertically polarized SLAR to detect and map oil spills during periods of calm seas has been well documented (Edgerton, et al, 1975). However, it wasn't until the performance of the AOSS II flight tests that a comparatively easy means was provided to directly compare data obtained with both vertically and horizontally polarized SLAR antennas while overflying an oil slick.

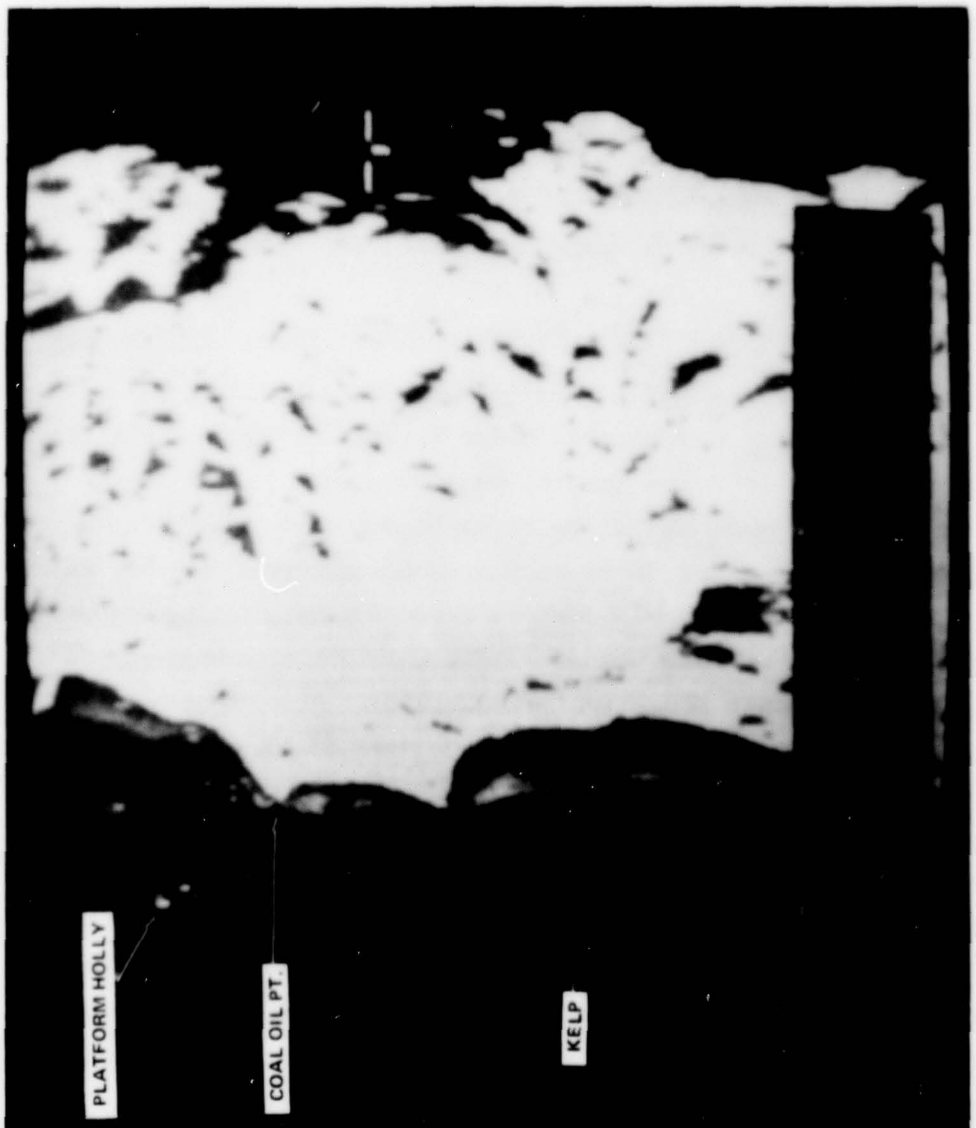


Figure 4-7. AOSS II SLAR, TV Image Displayed in the Right Only Antenna Look Mode

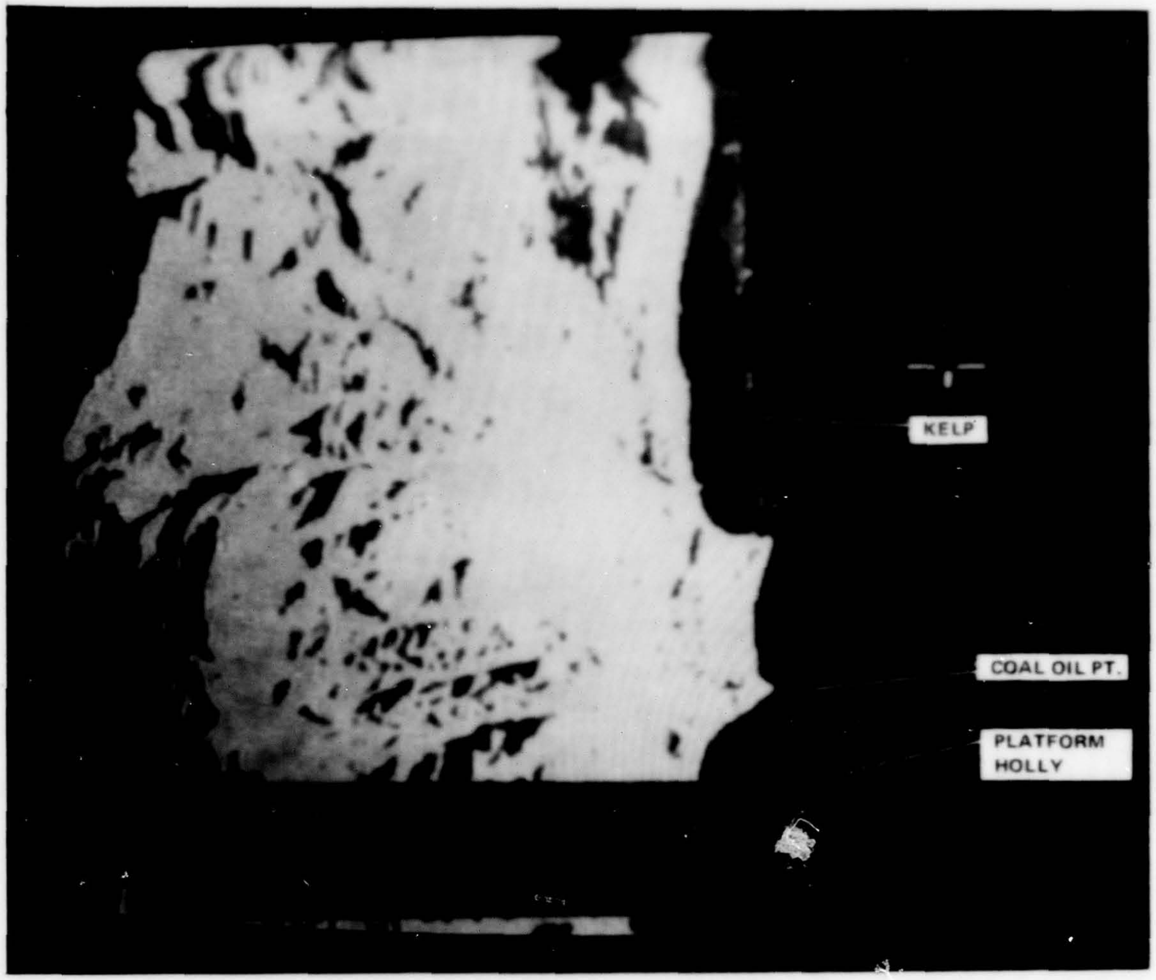


Figure 4-8. AOSS II SLAR, TV Image Displayed in the Left Only Antenna Look Mode

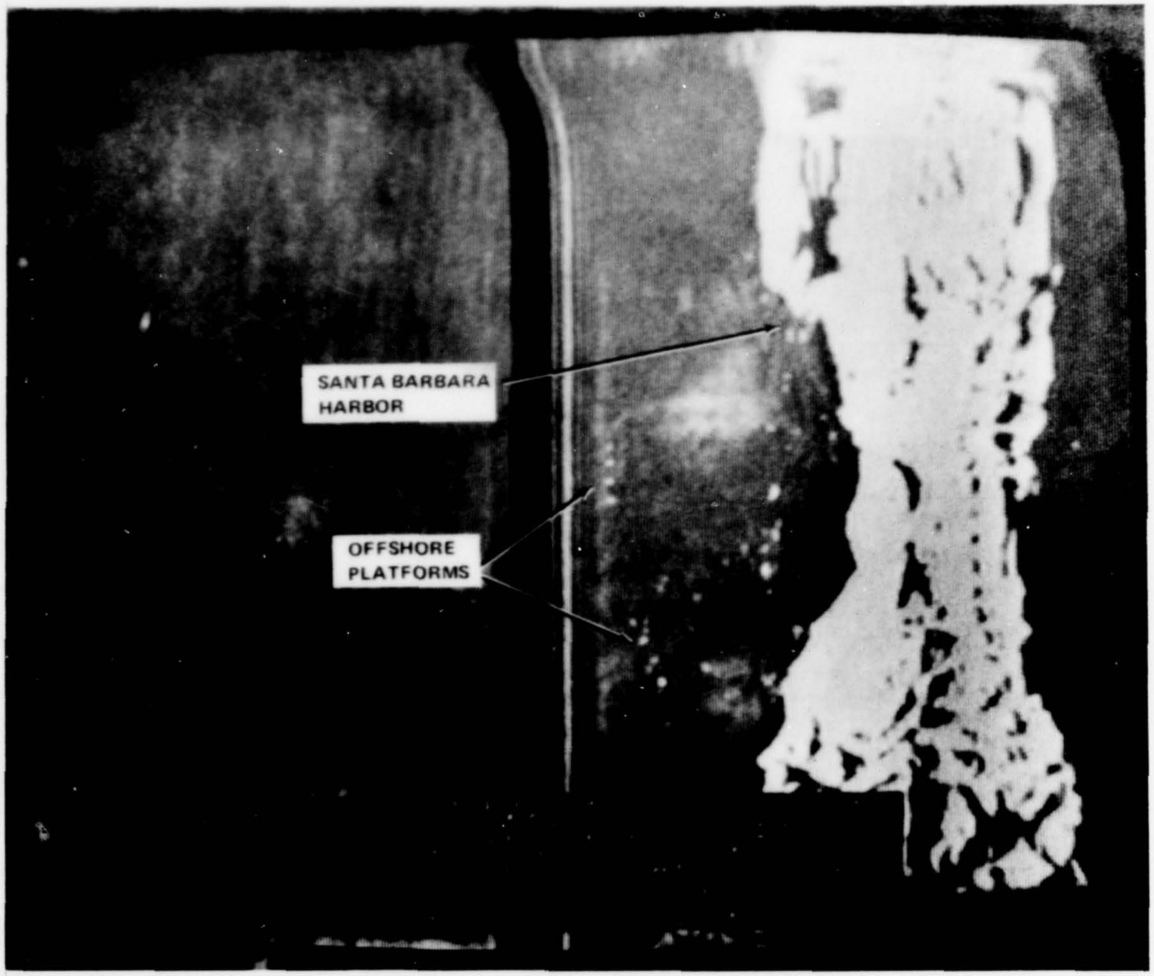


Figure 4-9. AOSS II SLAR, TV Image Being Displayed in the Both Antenna Look Mode

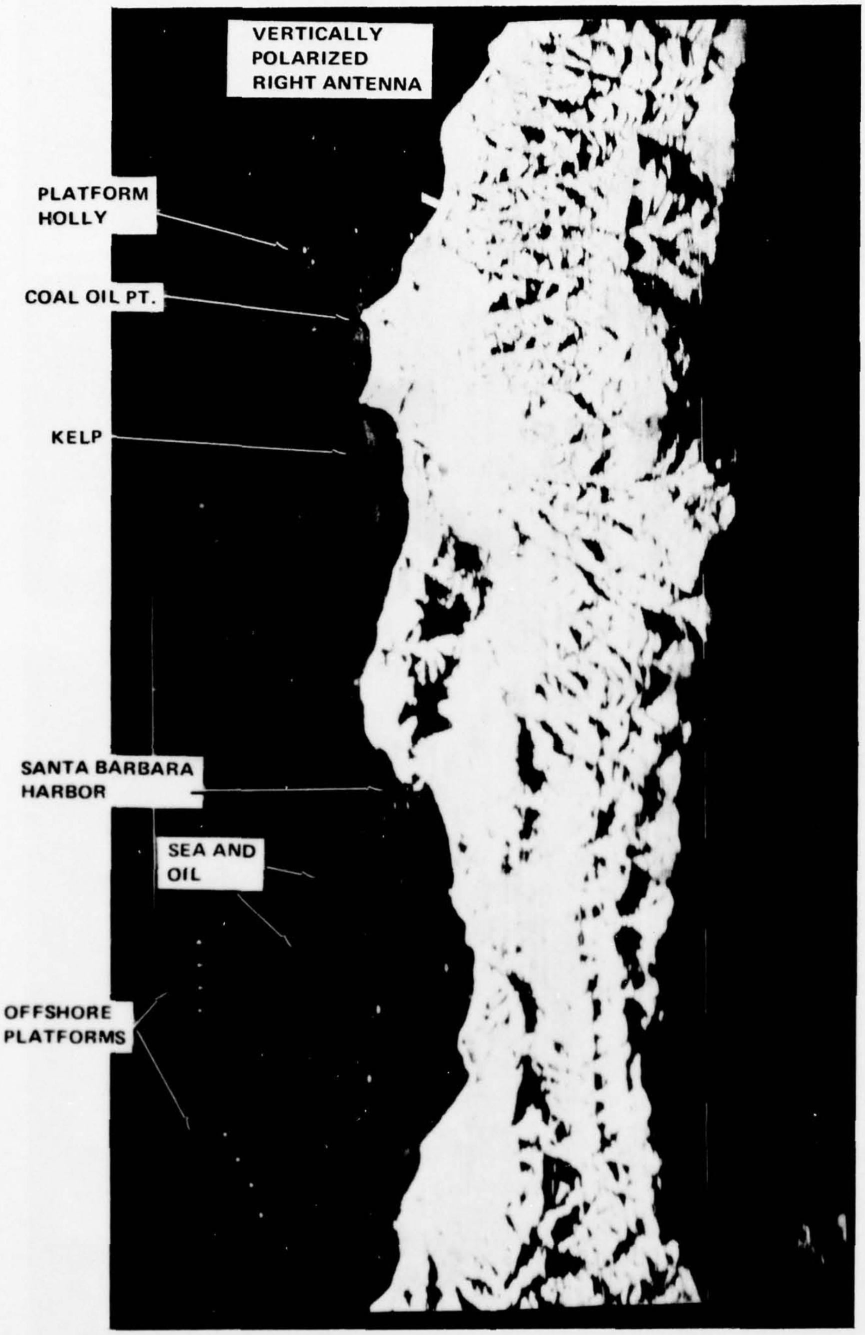


Figure 4-10. AOSS II SLAR Film Recorder Image Recorded in the Right Only Antenna Look Mode

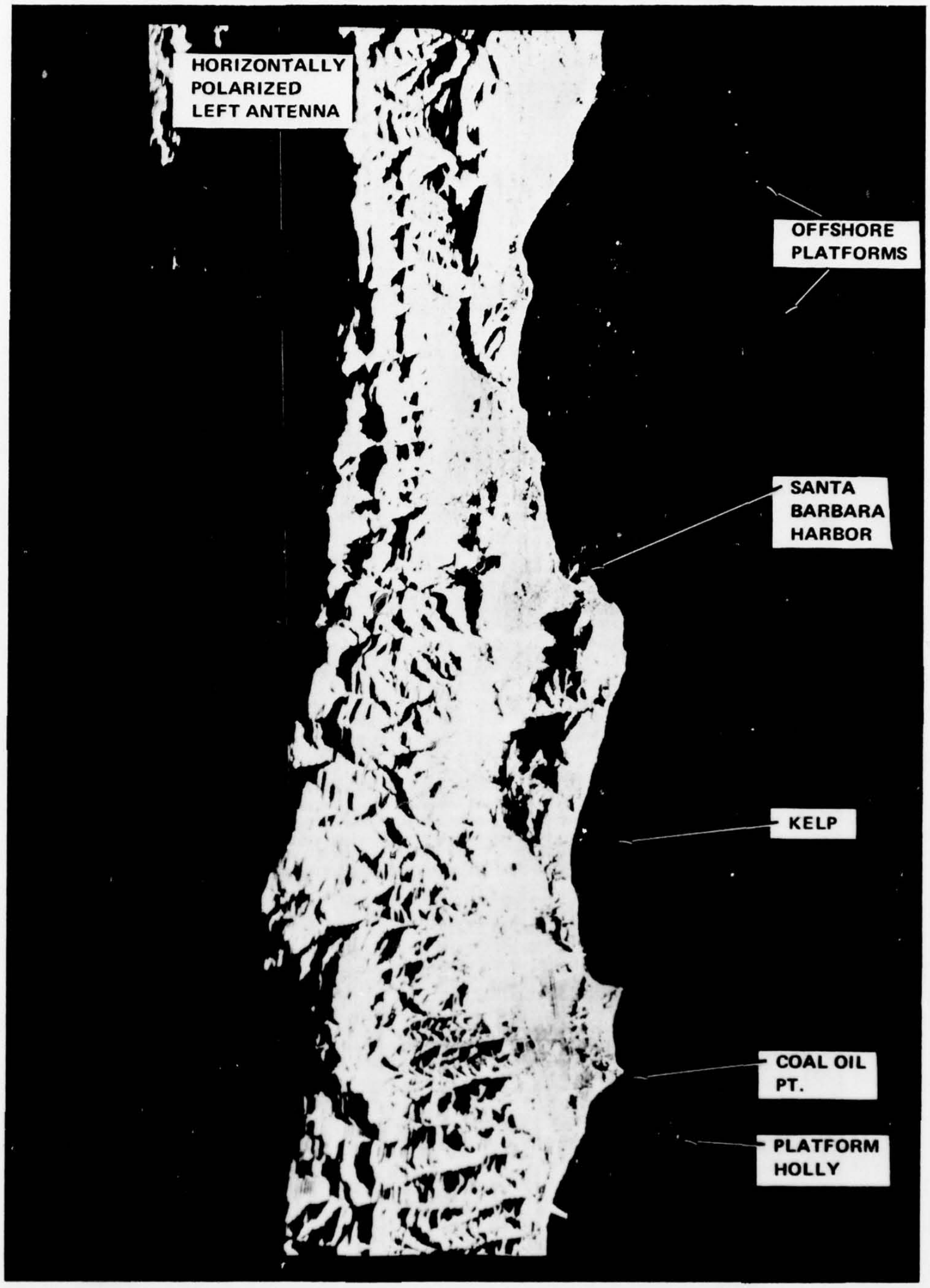


Figure 4-11. AOSS II SLAR Film Recorder Image Recorded in the Left Only Antenna Look Mode

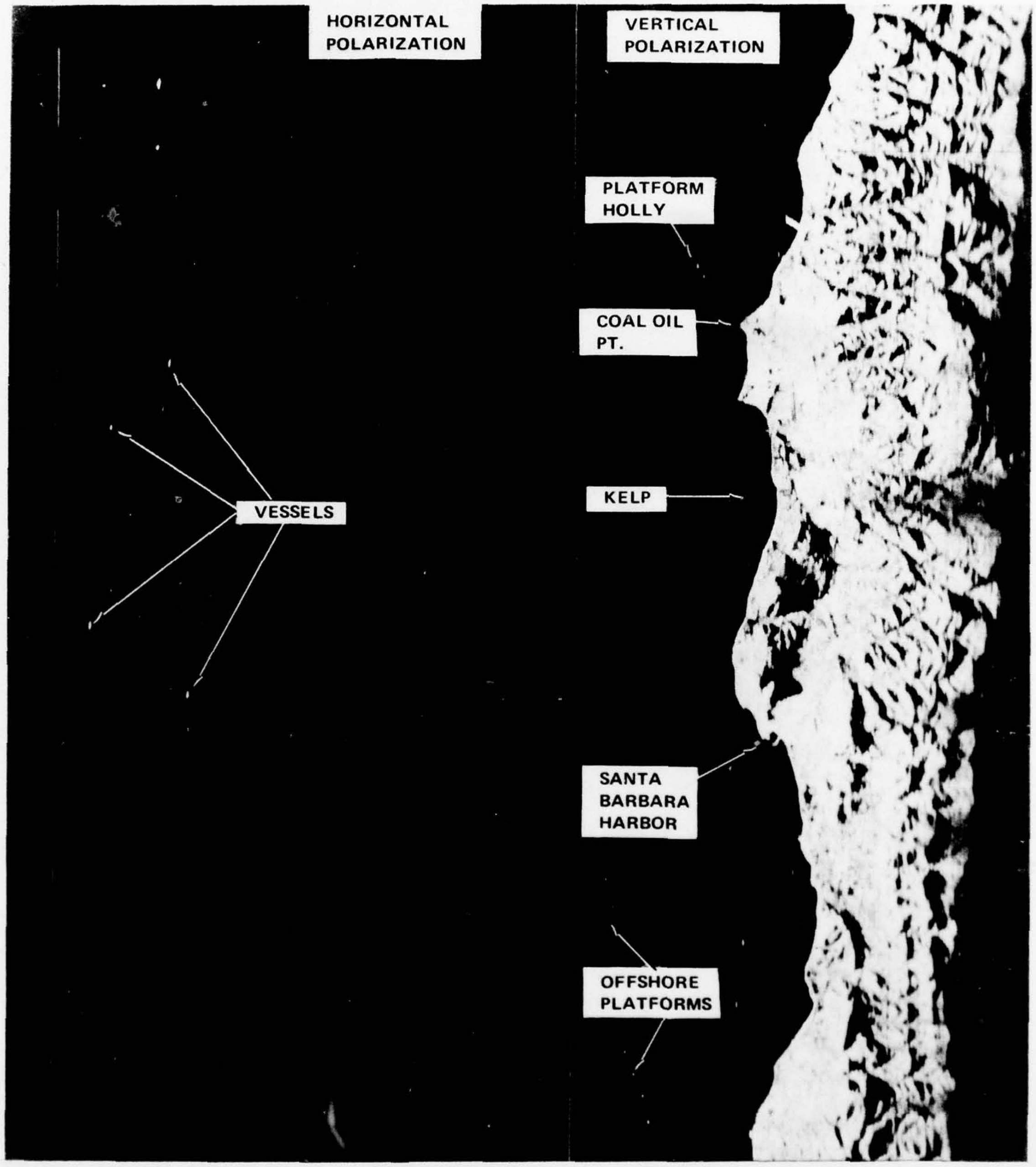


Figure 4-12. AOSS II SLAR Film Recorder Image Recorded in the Both Antenna Look Mode

On 7 April 1977 a series of SLAR data sets of the Santa Barbara coastal area were obtained at approximately 1200 hours local time. At this time, surface winds ranged from 3-5 knots and sea surface conditions appeared calm (very light chop with no visible white caps indicating a sea state ≤ 1).* Figures 4-10 and 4-13 represent right only antenna (vertically polarized) imagery obtained from the SLAR film recorder and TV display, respectively. Figures 4-11 and 4-14 show respective SLAR film recorder and TV displayed imagery, but in the left only antenna (horizontally polarized) look mode. Both sea state and oil streamers have been detected and are clearly shown in the vertically polarized imagery. Note that these features are absent in the horizontally polarized imagery, indicating an inability of the horizontally polarized antenna to detect oil during periods of low winds and calm seas.

Figure 4-15 provides a comparison of vertically and horizontally polarized imagery obtained on 3 March 1977. During these overflights, both wind (20-30 knots) and seas (wave heights $\approx$5-10 feet, SS $\approx$5-6) were the highest encountered during the flight test program.* Excessive aircraft roll occurred resulting in alternating light and dark colored banding across the imagery. The vertically polarized imagery clearly shows oil streaming both shoreward and to the east of Platform Holly. As shown by the horizontally polarized imagery, no oil and in fact, very little sea state was detected by the horizontally polarized antenna.

The reader is reminded that it is the suppression of sea state by the presence of an oil film that allows oil slicks to be detected with radar. Consequently, if sea state is not detected, oil cannot be detected. Figure 4-16 represents SLAR data obtained from the TV display while operating in the both antenna look mode (horizontally polarized antenna looking to the left and vertically polarized antenna looking to the right, simultaneously). This image was obtained on 30 March 1977 with what appeared to be uniform sea

*Wind speed and direction data obtained from various Santa Barbara Channel locations are given in Appendix B.

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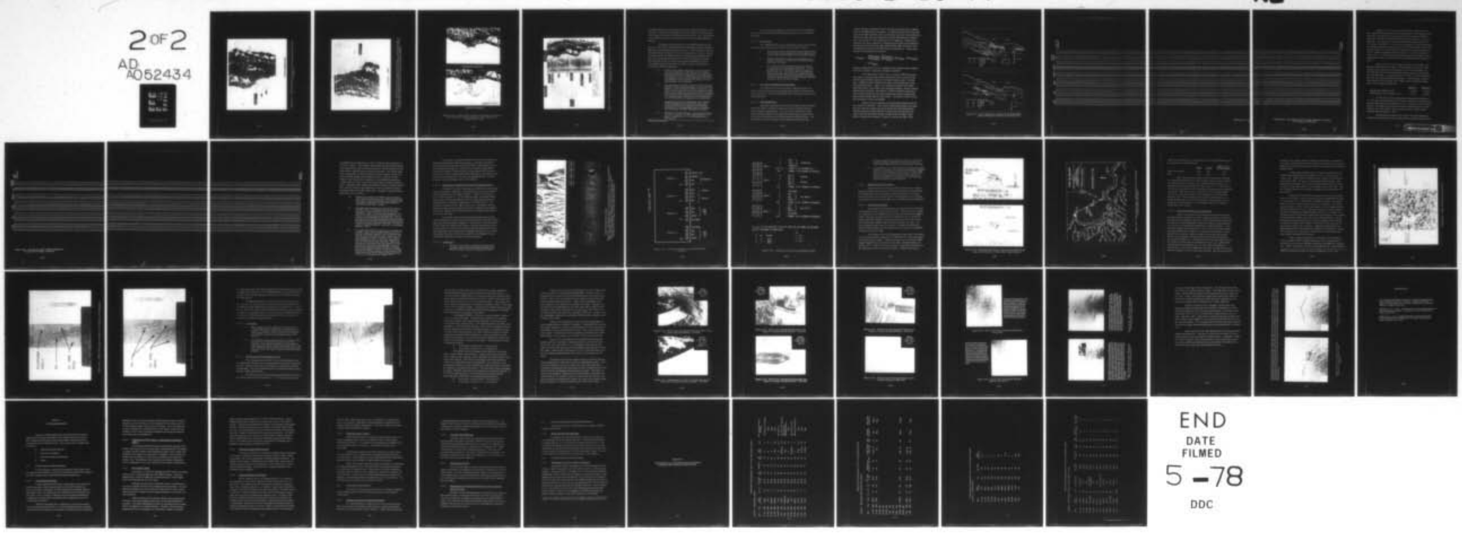

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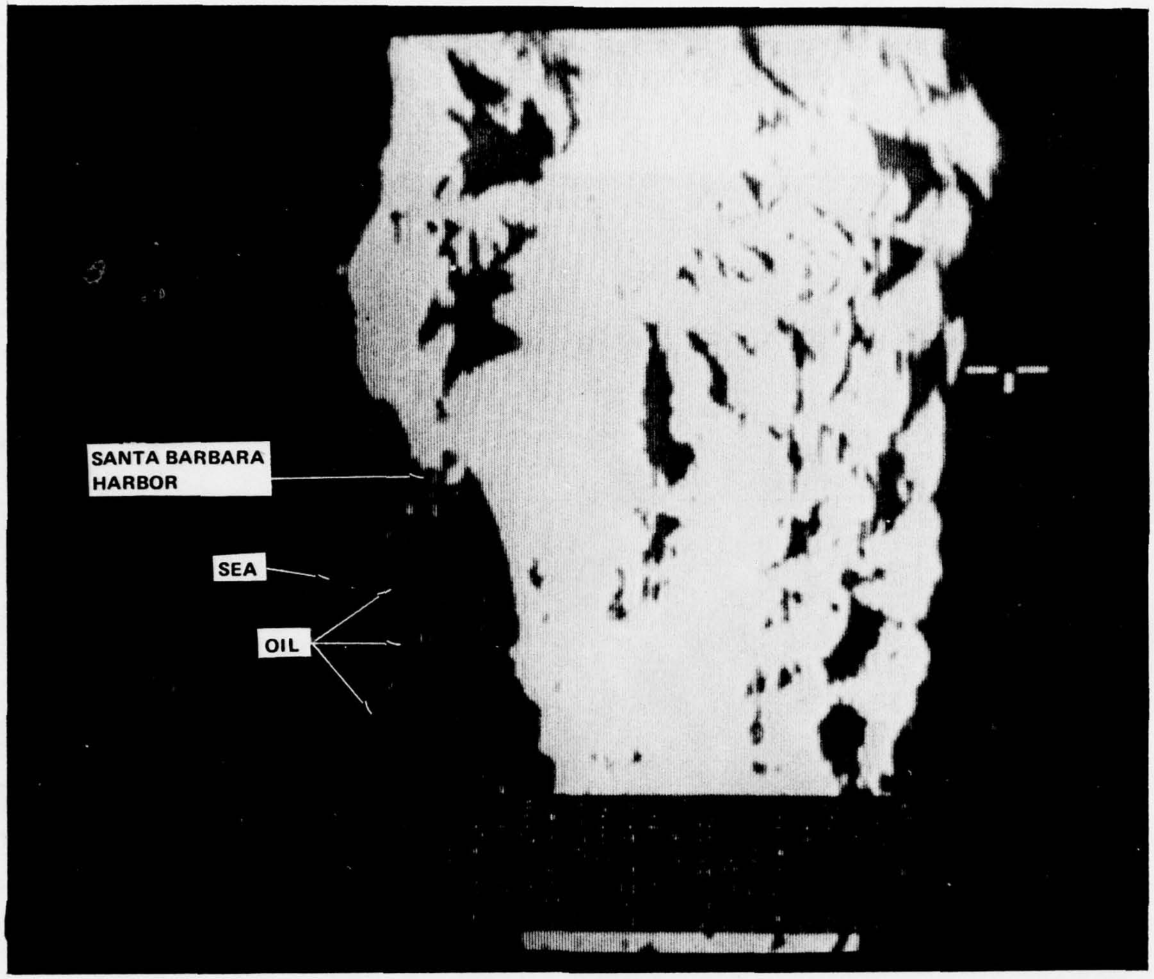


Figure 4-13. AOSS II Vertically Polarized SLAR Image Showing Sea and Oil (SS ≤ 1)

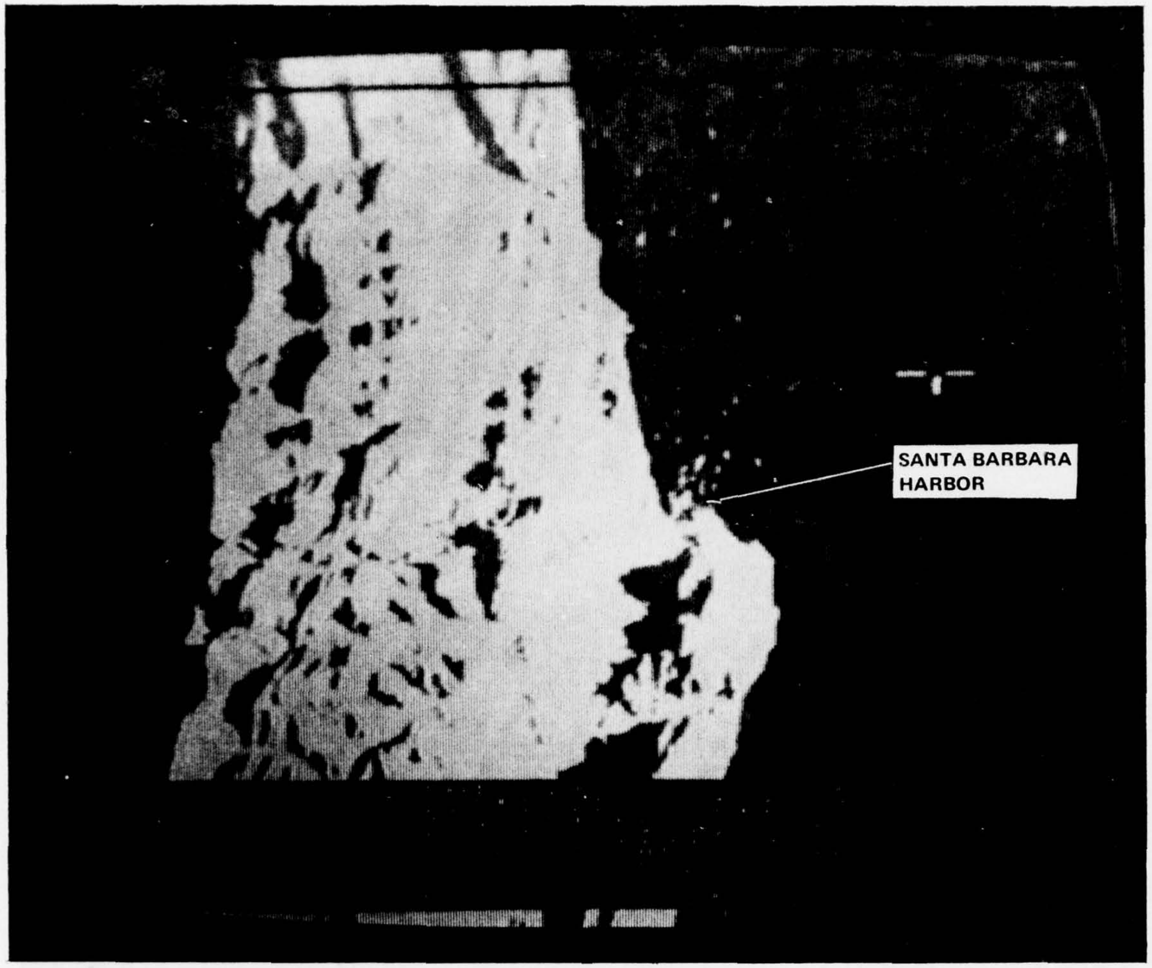
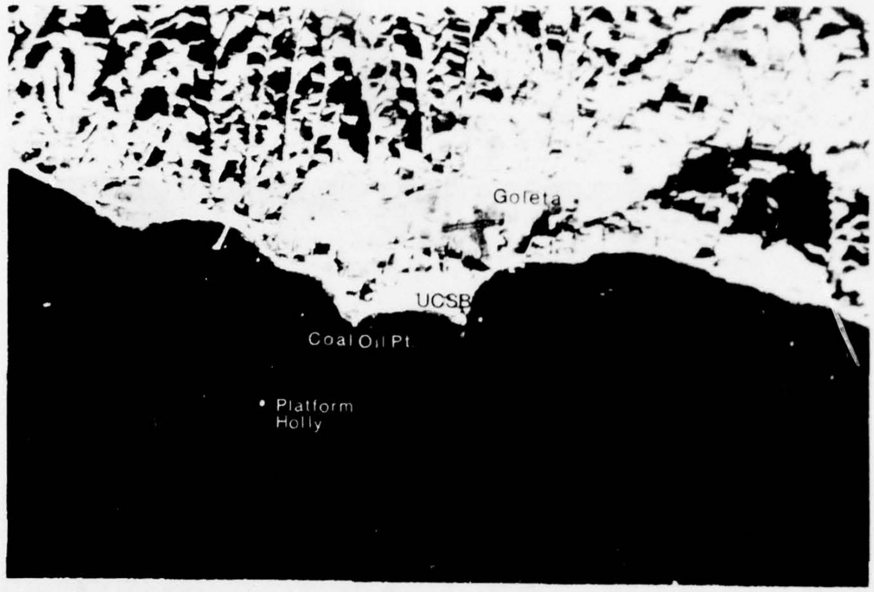
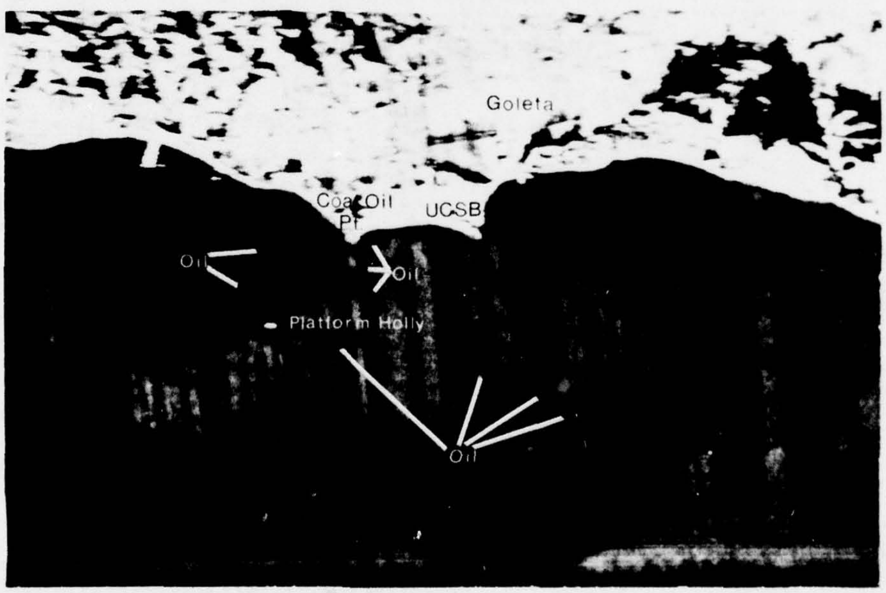


Figure 4-14. AOSS II Horizontally Polarized SLAR Image. Note the Absence of Sea Return which Indicates an Inability of the Horizontally Polarized Antenna to Detect Oil During Periods of Low Winds and Calm Seas (SS ≤ 1)



HORIZONTALLY POLARIZED



VERTICALLY POLARIZED

Figure 4-15. AOSS II SLAR Imagery Comparing the Ability of the Vertically and Horizontally Polarized Antennas to Detect Oil (SS $\approx$ 5-6)

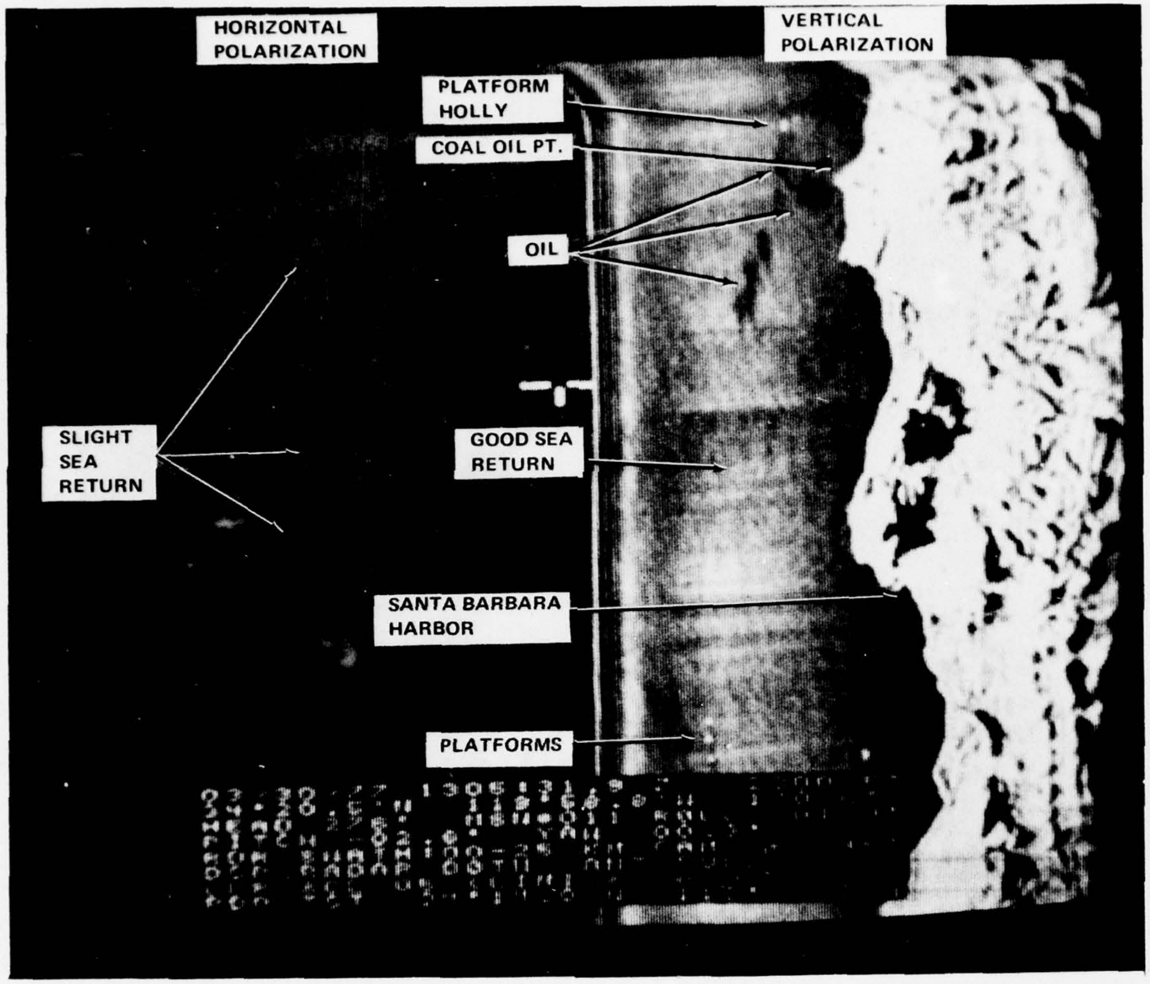


Figure 4-16. AOSS II SLAR Image Showing Vertically and Horizontally Polarized Sea Returns (SS $\approx$ 5)

conditions (sea state $\approx$5) existing on both the right and left sides of the aircraft*. Note the well-defined sea return and hence, the detection of oil obtained with the vertically polarized antenna. As in Figure 4-15, only a slight sea return was obtained with the horizontally polarized antenna.

Throughout the performance of the AOSS II flight test program, oil was never detected with the horizontally polarized antenna. Sea states encountered ranged from $\leq$1 to 6. The fact that oil was not detected during sea states of $\leq$1 to 3 was expected. However, during sea states of $\geq$4, the ability of the horizontally polarized antenna to detect oil should approach that of the vertically polarized antenna. The following factors provide some possible explanations why the horizontally polarized antenna was unable to detect oil during the occurrence of these conditions.

a. As part of the SLAR modification, 6 dB of attenuation was introduced into the 16-foot horizontally polarized antenna to compensate for its higher gain. Toward the end of the flight tests, this attenuation was determined not to be operationally required and was disabled. Unfortunately, sea states >3 were subsequently not encountered.

b. Gain settings on the film recorder were improperly adjusted. This caused degradation in film recorder imagery on both antenna channels, but did not cause a lack of sea return from the horizontally polarized antenna to be displayed on the real-time TV monitor. This condition was subsequently corrected resulting in a display improvement for both the horizontally and vertically polarized signals on the SLAR film.

c. A significant amount of SLAR data were obtained while operating in the both antenna look mode. Operation in this mode results in only half the average power being radiated from each antenna and accounts for a slight degradation in signal.

d. Subsequent to flight testing, it was determined that the 16-foot antenna was tilted approximately 0.5° upward, resulting in a 1 to 2 dB degradation in performance.

*Visual observations.

It is felt that a combination of the above factors caused the 16-foot, horizontally polarized antenna performance to be less than predicted.

4.4.2.4 Conclusions

The AOSS II SLAR met all modification design requirements. The following conclusions are drawn from the flight test data.

a. The target/cursor consistently located targets within the accuracy of the INS, and will be a valuable tool for the Coast Guard's MEP, ELT and SAR missions.

b. AOSS II satisfactorily displays all SLAR antenna modes of operation, both on the TV display and the SLAR film recorder.

c. At no time during the flight test program did the horizontally polarized antenna detect oil. This is probably due to a combination of factors cited in Section 4.4.2.3. The writers feel that additional flight testing during periods of sea states greater than three need to be performed before an adequate evaluation of the ability of the horizontally polarized antenna to detect oil can be made.

4.4.3 Line Scanner Modification Evaluation

The objectives of the line scanner (LS) flight tests were (1) to verify the airborne remote temperature (ART) sensing modification, and (2) to verify the simultaneous UV and IR hard copy recording modification.

4.4.3.1 ART Modification

The ART modification allows the 8-13 μm infrared channel of the line scanner system to sense and record calibrated thermometric surface temperatures. This is done by comparing surface sensed infrared signals with calibrated temperatures obtained from two thermo-electrically controlled blackbodies (BB1 and BB2). The LS interface circuitry samples video signals obtained from the

surface and each calibration source and then transmits them in digital form to the AOSS II data processor. By subtracting the BB1 video data value from BB2 video data value and dividing the result by the difference between the BB1 physical temperature and the BB2 physical temperature, the number of video counts per $^{\circ}C$ are obtained. Surface temperatures are then computed by multiplying this value by the difference between the surface IR video data value and the BB1 video data value and adding this result to the BB1 physical temperature. These calculations are summarized as follows:

$$IR_{TEMP} = \left(\frac{BB2_{TEMP} - BB1_{TEMP}}{BB2_{VIDEO} - BB1_{VIDEO}}\right) \times \left(IR_{VIDEO} - BB1_{VIDEO}\right)$$

$$+ \; BB1_{BEMP}$$

Surface temperatures ($^{\circ}C$) are tabulated on the offline printer together with time, latitude, longitude, heading and altitude.

On 8 March and 5 April 1977, a series of ART flight tests were flown over open water and scattered oil in the vicinity of Coal Oil Point and Platform Holly off the Santa Barbara coast. On both days, UCSB personnel obtained sea surface truth temperature data along the flight lines. Figure 4-17 shows the 8 March and 5 April ART flight lines, sea surface truth sampling stations, and sea surface temperatures obtained. On 8 March, a PRT-5 infrared radiometer was carried onboard the aircraft to obtain sea surface temperature data simultaneously with the line scanner. The PRT-5 was not available during the 5 April overflights.

Figure 4-18 is a printout of the ART data obtained with the line scanner on 8 March. Only center temperatures (nadir scan position) are used for comparison since the left and right temperature columns represent scan positions 45 degrees to the left and to the right of the aircraft where neither surface truth nor PRT-5 data (nadir viewing) were obtained. Figure 4-19 gives the PRT-5 sea

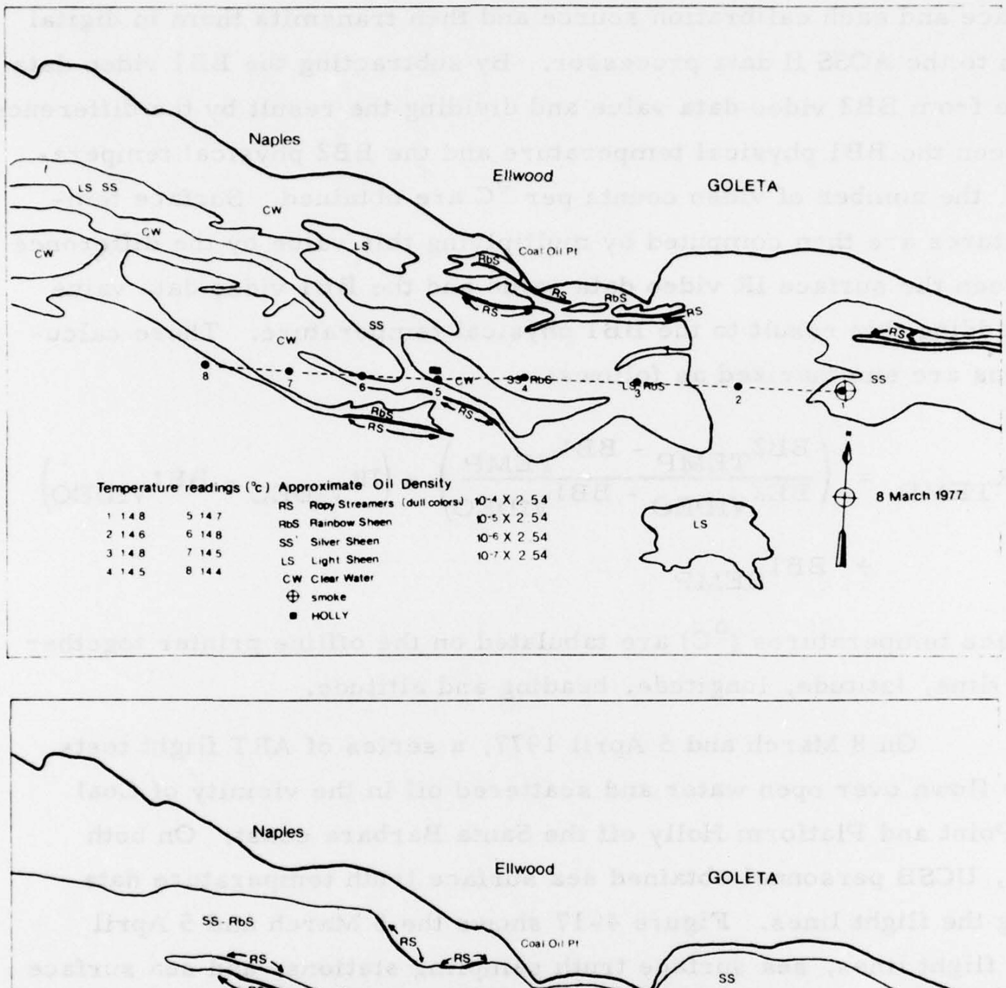


Figure 4-17. ART Flight Lines and Surface Truth Sampling Stations Utilized on 8 March and 5 April 1977

TIME	LAT	LONG.	HEADING	ALTITUDE	SURFACE TEMP (^{o}C)			
14:04:02	34:23.0 N	119:45.8 W	293.6	2400	12.0	13.3	12.6	— START RUN
14:04:02	34:23.0 N	119:45.8 W	293.6	2400	12.0	13.3	12.6	(STATION 1)
14:04:03	34:23.0 N	119:45.8 W	293.7	2400	12.2	13.3	12.8	
14:04:04	34:23.1 N	119:45.9 W	293.6	2400	12.1	13.2	12.7	
14:04:05	34:23.1 N	119:45.9 W	293.5	2400	12.2	13.2	12.8	
14:04:06	34:23.1 N	119:45.9 W	293.3	2400	11.9	13.1	12.8	
14:04:07	34:23.0 N	119:45.9 W	293.2	2400	12.5	13.3	13.0	
14:04:08	34:23.1 N	119:45.9 W	293.1	2400	12.3	13.3	13.1	
14:04:09	34:23.1 N	119:46.1 W	293.1	2400	12.3	13.2	13.0	
14:04:10	34:23.1 N	119:46.2 W	293.0	2400	12.2	13.2	12.9	
14:04:11	34:23.1 N	119:46.2 W	292.9	2400	11.8	13.1	12.8	
14:04:12	34:23.2 N	119:46.2 W	292.8	2400	11.9	13.1	12.8	
14:04:13	34:23.2 N	119:46.3 W	292.6	2400	12.1	13.2	12.9	
14:04:14	34:23.2 N	119:46.3 W	292.5	2400	11.9	13.1	12.8	
14:04:15	34:23.2 N	119:46.4 W	292.4	2400	11.8	12.9	12.8	
14:04:16	34:23.2 N	119:46.4 W	292.3	2400	11.6	13.0	12.9	
14:04:17	34:23.2 N	119:46.4 W	292.4	2400	11.7	13.0	12.9	
14:04:18	34:23.2 N	119:46.4 W	292.4	2400	11.6	13.0	12.9	
14:04:19	34:23.2 N	119:46.5 W	292.4	2400	11.6	13.0	12.9	
14:04:20	34:23.3 N	119:46.6 W	292.4	2400	11.5	13.0	12.8	
14:04:21	34:23.3 N	119:46.6 W	292.3	2400	11.2	12.9	12.8	
14:04:22	34:23.3 N	119:46.6 W	292.2	2400	11.3	12.9	12.8	
14:04:23	34:23.3 N	119:46.8 W	292.2	2400	11.3	13.0	12.8	
14:04:24	34:23.3 N	119:46.8 W	292.3	2400	11.4	12.9	12.8	
14:04:25	34:23.4 N	119:46.9 W	292.5	2400	11.5	13.0	12.9	
14:04:26	34:23.4 N	119:47.0 W	292.8	2400	11.5	12.9	12.9	
14:04:27	34:23.4 N	119:47.0 W	292.9	2400	11.6	12.9	12.9	
14:04:28	34:23.4 N	119:47.0 W	292.9	2400	11.7	13.0	13.0	
14:04:29	34:23.4 N	119:47.1 W	292.8	2400	11.9	13.2	13.1	
14:04:30	34:23.4 N	119:47.1 W	292.7	2400	12.0	13.4	13.4	
14:04:31	34:23.4 N	119:47.1 W	292.6	2400	12.0	13.2	13.1	
14:04:32	34:23.6 N	119:47.2 W	292.7	2400	12.4	13.2	13.1	
14:04:33	34:23.6 N	119:47.2 W	293.0	2400	12.6	13.3	13.0	
14:04:34	34:23.7 N	119:47.2 W	293.3	2400	12.6	13.2	12.9	
14:04:35	34:23.6 N	119:47.3 W	293.5	2400	12.7	13.1	12.9	
14:04:36	34:23.6 N	119:47.5 W	293.5	2400	12.7	13.2	12.9	
14:04:37	34:23.6 N	119:47.6 W	293.3	2400	12.7	13.2	12.8	
14:04:38	34:23.7 N	119:47.6 W	293.0	2400	12.6	13.1	12.8	
14:04:39	34:23.7 N	119:47.6 W	292.7	2400	12.7	13.1	12.8	
14:04:40	34:23.7 N	119:47.6 W	292.5	2400	12.6	13.1	12.8	
14:04:41	34:23.7 N	119:47.8 W	292.3	2400	12.6	13.2	12.9	
14:04:42	34:23.7 N	119:47.7 W	292.2	2400	12.7	13.3	13.0	
14:04:43	34:23.7 N	119:47.8 W	292.1	2400	12.6	13.2	12.9	
14:04:44	34:23.7 N	119:47.8 W	292.0	2400	12.7	13.2	12.8	
14:04:45	34:23.7 N	119:47.9 W	291.9	2400	12.7	13.2	12.9	
14:04:46	34:23.7 N	119:47.9 W	291.8	2400	12.7	13.2	12.9	
14:04:47	34:23.8 N	119:47.9 W	291.6	2400	10.5	13.3	12.9	
14:04:48	34:23.8 N	119:48.0 W	291.3	2400	10.8	13.3	13.1	
14:04:49	34:23.8 N	119:48.2 W	291.0	2400	10.4	13.3	13.1	
14:04:50	34:23.8 N	119:48.2 W	290.8	2400	9.8	13.6	13.2	
14:04:51	34:23.9 N	119:48.3 W	290.6	2400	10.7	13.6	13.3	
14:04:52	34:23.9 N	119:48.2 W	290.5	2400	11.0	13.7	13.4	
14:04:53	34:23.9 N	119:48.3 W	290.3	2400	11.6	13.6	13.3	
14:04:54	34:23.9 N	119:48.4 W	290.2	2400	11.8	13.5	13.2	
14:04:55	34:23.9 N	119:48.4 W	290.1	2400	11.1	13.5	13.2	
14:04:56	34:23.9 N	119:48.4 W	289.9	2400	10.5	13.5	13.2	
14:04:57	34:23.9 N	119:48.5 W	289.7	2400	10.3	13.5	13.2	
14:04:58	34:23.9 N	119:48.5 W	289.6	2400	10.8	13.5	13.2	
14:04:59	34:24.0 N	119:48.6 W	289.4	2400	10.8	13.5	13.2	
14:05:01	34:24.0 N	119:48.6 W	289.2	2400	11.4	13.5	13.3	

14:04:44	34:23.7 N	119:47.8 W	292.0	2400	12.7	13.2	12.8
14:04:45	34:23.7 N	119:47.9 W	291.9	2400	12.7	13.2	12.9
14:04:46	34:23.7 N	119:47.9 W	291.8	2400	12.7	13.2	12.9
14:04:47	34:23.8 N	119:47.9 W	291.6	2400	10.5	13.3	12.9
14:04:48	34:23.8 N	119:48.0 W	291.3	2400	10.8	13.3	13.1
14:04:49	34:23.8 N	119:48.2 W	291.0	2400	10.4	13.3	13.1
14:04:50	34:23.8 N	119:48.2 W	290.8	2400	9.8	13.6	13.2
14:04:51	34:23.9 N	119:48.3 W	290.6	2400	10.7	13.6	13.3
14:04:52	34:23.9 N	119:48.2 W	290.5	2400	11.0	13.7	13.4
14:04:53	34:23.9 N	119:48.3 W	290.3	2400	11.6	13.6	13.3
14:04:54	34:23.9 N	119:48.4 W	290.2	2400	11.8	13.5	13.2
14:04:55	34:23.9 N	119:48.4 W	290.1	2400	11.1	13.5	13.2
14:04:56	34:23.9 N	119:48.4 W	289.9	2400	10.5	13.5	13.2
14:04:57	34:23.9 N	119:48.5 W	289.7	2400	10.3	13.5	13.2
14:04:58	34:23.9 N	119:48.5 W	289.6	2400	10.8	13.5	13.2
14:04:59	34:24.0 N	119:48.6 W	289.4	2400	10.8	13.5	13.2
14:05:01	34:24.0 N	119:48.6 W	289.2	2400	11.4	13.5	13.3
14:05:01	34:24.0 N	119:48.6 W	289.2	2400	11.0	13.5	13.2
14:05:02	34:24.0 N	119:48.8 W	289.1	2400	10.7	13.4	13.2
14:05:03	34:24.0 N	119:48.8 W	289.0	2400	10.7	13.5	13.3
14:05:04	34:24.0 N	119:48.9 W	289.0	2400	10.5	13.5	13.3
14:05:05	34:24.0 N	119:49.0 W	289.1	2400	10.7	13.5	13.4
14:05:06	34:24.0 N	119:49.0 W	289.2	2400	10.7	13.6	13.4
14:05:07	34:24.0 N	119:49.0 W	289.1	2400	10.2	13.6	13.4
14:05:08	34:24.1 N	119:49.0 W	288.8	2400	10.5	13.6	13.3
14:05:09	34:24.1 N	119:49.1 W	288.6	2400	10.7	13.8	13.4
14:05:10	34:24.1 N	119:49.2 W	288.5	2400	10.6	13.7	13.3
14:05:11	34:24.1 N	119:49.2 W	288.5	2400	10.6	13.6	13.3
14:05:12	34:24.3 N	119:49.3 W	288.7	2400	10.0	13.7	13.4
14:05:13	34:24.1 N	119:49.3 W	288.8	2400	9.4	13.4	13.3
14:05:14	34:24.1 N	119:49.3 W	288.8	2400	8.7	13.4	13.2
14:05:15	34:24.1 N	119:49.5 W	288.8	2400	9.0	13.5	13.4
14:05:16	34:24.3 N	119:49.5 W	288.7	2400	9.3	13.6	13.5
14:05:17	34:24.3 N	119:49.5 W	288.7	2400	9.2	13.5	13.4
14:05:18	34:24.3 N	119:49.5 W	288.7	2400	9.7	13.6	13.5
14:05:19	34:24.3 N	119:49.6 W	288.8	2400	10.1	13.6	13.5
14:05:20	34:24.4 N	119:49.8 W	288.8	2400	10.8	13.7	13.5
14:05:21	34:24.4 N	119:49.8 W	288.8	2400	11.0	13.8	13.5
14:05:22	34:24.3 N	119:49.8 W	288.7	2400	10.9	13.8	13.4
14:05:23	34:24.3 N	119:49.8 W	288.5	2400	11.3	13.9	13.4
14:05:24	34:24.3 N	119:49.8 W	288.4	2400	11.8	13.8	13.4
14:05:25	34:24.3 N	119:50.0 W	288.3	2400	12.3	13.9	13.5
14:05:26	34:24.4 N	119:50.0 W	288.3	2400	12.3	13.6	13.5
14:05:27	34:24.4 N	119:50.0 W	288.2	2400	12.3	13.8	13.5
14:05:28	34:24.4 N	119:50.0 W	288.1	2400	12.3	13.8	13.6
14:05:29	34:24.4 N	119:50.0 W	287.9	2400	12.3	13.8	13.6
14:05:30	34:24.4 N	119:50.3 W	287.7	2400	12.1	13.8	13.7
14:05:31	34:24.4 N	119:50.4 W	287.7	2400	12.1	13.8	13.7
14:05:32	34:24.5 N	119:50.4 W	287.7	2400	12.1	13.9	13.8
14:05:33	34:24.5 N	119:50.4 W	287.7	2400	12.3	13.9	13.8
14:05:34	34:24.5 N	119:50.5 W	287.8	2400	12.9	13.8	13.6
14:05:35	34:24.5 N	119:50.5 W	287.8	2400	12.7	13.9	13.5
14:05:36	34:24.5 N	119:50.5 W	287.8	2400	12.8	13.9	13.4
14:05:37	34:24.6 N	119:50.6 W	287.6	2400	12.4	14.0	13.5
14:05:38	34:24.6 N	119:50.6 W	287.4	2400	12.2	13.9	13.5
14:05:39	34:24.6 N	119:50.6 W	287.1	2400	12.4	14.0	13.5
14:05:40	34:24.6 N	119:50.7 W	286.8	2400	12.1	13.9	13.5
14:05:41	34:24.6 N	119:50.7 W	286.7	2400	12.3	14.0	13.6
14:05:42	34:24.6 N	119:50.9 W	286.6	2400	12.0	13.9	13.4
14:05:43	34:24.7 N	119:50.9 W	286.6	2400	12.0	13.9	13.4
14:05:44	34:24.6 N	119:51.0 W	286.6	2400	12.2	13.9	13.4
14:05:45	34:24.6 N	119:51.0 W	286.6	2400	12.3	13.9	13.4
14:05:46	34:24.6 N	119:51.0 W	286.5	2400	12.3	13.9	13.3
14:05:47	34:24.6 N	119:51.1 W	286.4	2400	12.6	13.8	13.3
14:05:48	34:24.7 N	119:51.2 W	286.2	2400	12.8	13.5	13.4
14:05:49	34:24.7 N	119:51.2 W	286.1	2400	12.8	13.9	13.4

Figure 4-18. Lin

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14:05:26	34:24.4 N	119:50.0 W	288.3	2400	12.3	13.6	13.5
14:05:27	34:24.4 N	119:50.0 W	288.2	2400	12.3	13.8	13.5
14:05:28	34:24.4 N	119:50.0 W	288.1	2400	12.3	13.8	13.6
14:05:29	34:24.4 N	119:50.0 W	287.9	2400	12.3	13.8	13.6
14:05:30	34:24.4 N	119:50.3 W	287.7	2400	12.1	13.8	13.7
14:05:31	34:24.4 N	119:50.4 W	287.7	2400	12.1	13.8	13.7
14:05:32	34:24.5 N	119:50.4 W	287.7	2400	12.1	13.9	13.8
14:05:33	34:24.5 N	119:50.4 W	287.7	2400	12.3	13.9	13.8
14:05:34	34:24.5 N	119:50.5 W	287.8	2400	12.9	13.8	13.6
14:05:35	34:24.5 N	119:50.5 W	287.8	2400	12.7	13.9	13.5
14:05:36	34:24.5 N	119:50.5 W	287.8	2400	12.8	13.9	13.4
14:05:37	34:24.6 N	119:50.6 W	287.6	2400	12.4	14.0	13.5
14:05:38	34:24.6 N	119:50.6 W	287.4	2400	12.2	13.9	13.5
14:05:39	34:24.6 N	119:50.6 W	287.1	2400	12.4	14.0	13.5
14:05:40	34:24.6 N	119:50.7 W	286.8	2400	12.1	13.9	13.5
14:05:41	34:24.6 N	119:50.7 W	286.7	2400	12.3	14.0	13.6
14:05:42	34:24.6 N	119:50.9 W	286.6	2400	12.0	13.9	13.4
14:05:43	34:24.7 N	119:50.9 W	286.6	2400	12.0	13.9	13.4
14:05:44	34:24.6 N	119:51.0 W	286.6	2400	12.2	13.9	13.4
14:05:45	34:24.6 N	119:51.0 W	286.6	2400	12.3	13.9	13.4
14:05:46	34:24.6 N	119:51.0 W	286.5	2400	12.3	13.9	13.3
14:05:47	34:24.6 N	119:51.1 W	286.4	2400	12.6	13.8	13.3
14:05:48	34:24.7 N	119:51.2 W	286.2	2400	12.8	13.5	13.4
14:05:49	34:24.7 N	119:51.2 W	286.1	2400	12.8	13.9	13.4
14:05:50	34:24.7 N	119:51.2 W	285.9	2400	12.7	13.9	13.4
14:05:51	34:24.6 N	119:51.3 W	285.6	2400	12.5	13.9	13.5
14:05:52	34:24.8 N	119:51.4 W	285.4	2400	12.5	13.9	13.5
14:05:53	34:24.8 N	119:51.4 W	285.1	2400	12.4	13.8	13.4
14:05:54	34:24.8 N	119:51.4 W	285.0	2400	11.6	13.8	13.5
14:05:55	34:24.8 N	119:51.4 W	284.9	2400	11.7	13.9	13.6
14:05:56	34:24.8 N	119:51.6 W	284.8	2400	11.6	13.8	13.4
14:05:57	34:24.8 N	119:51.7 W	284.6	2400	11.8	13.8	13.5
14:05:58	34:24.8 N	119:51.7 W	284.4	2400	11.8	13.8	13.5
14:05:59	34:24.8 N	119:51.7 W	284.2	2400	11.6	13.8	13.6
14:06:01	34:24.8 N	119:51.8 W	284.1	2400	11.5	13.8	13.7
14:06:01	34:24.8 N	119:51.8 W	284.0	2400	11.6	13.9	13.6
14:06:02	34:24.8 N	119:51.8 W	284.0	2400	11.7	13.9	13.7
14:06:03	34:24.8 N	119:52.0 W	284.1	2400	11.6	13.9	13.6
14:06:04	34:24.8 N	119:52.0 W	284.1	2400	11.3	13.9	13.6
14:06:05	34:24.8 N	119:52.0 W	284.2	2400	11.1	13.9	13.6
14:06:06	34:24.8 N	119:52.1 W	284.4	2400	10.8	13.9	13.7
14:06:07	34:24.8 N	119:52.1 W	284.5	2400	10.4	14.0	13.7
14:06:08	34:24.8 N	119:52.1 W	284.8	2400	10.3	14.0	13.7
14:06:09	34:24.8 N	119:52.3 W	285.0	2400	9.8	14.0	13.7
14:06:10	34:24.8 N	119:52.4 W	285.2	2400	9.8	14.0	13.6
14:06:11	34:25.0 N	119:52.5 W	285.4	2400	9.8	14.0	13.7
14:06:12	34:25.0 N	119:52.5 W	285.6	2400	9.5	14.0	13.6
14:06:13	34:25.1 N	119:52.5 W	285.8	2400	9.7	14.1	12.5
14:06:14	34:25.0 N	119:52.5 W	286.1	2400	10.1	14.2	13.4
14:06:15	34:25.1 N	119:52.5 W	286.4	2400	10.2	14.2	13.7
14:06:16	34:25.1 N	119:52.6 W	286.7	2400	10.4	14.1	13.2
14:06:17	34:25.1 N	119:52.6 W	286.9	2400	10.7	14.1	12.6
14:06:18	34:25.1 N	119:52.7 W	286.9	2400	10.7	14.1	13.1
14:06:19	34:25.1 N	119:52.9 W	286.9	2400	10.9	13.9	13.2
14:06:20	34:25.1 N	119:52.9 W	286.9	2400	11.5	14.0	13.6
14:06:21	34:25.1 N	119:53.0 W	286.8	2400	11.7	14.0	13.6
14:06:22	34:25.1 N	119:53.0 W	286.8	2400	12.1	13.9	13.5
14:06:23	34:25.1 N	119:53.0 W	286.7	2400	12.6	13.9	13.5 – END RUN (STATION 5)

Figure 4-18. Line Scanner ART Printout Obtained on 8 March 1977 (Altitude = 2400 feet)

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Stations 1 and 5 were chosen for direct comparison since they represented the start and end of the flight line and readily provide positional correlation for the data (both the line scanner and PRT-5 data were manually marked when the aircraft was directly over these stations). Note the nearly identical temperatures obtained with the line scanner and PRT-5. Also note the similarity in trend of gradually increasing temperature values ($\approx$13.2 to 14.0°C) obtained with the line scanner (Figure 4-18) and the PRT-5 (Figure 4-19) between Stations 1 and 5. Surface truth data obtained (Figure 4-17) tend to be higher in value ($\approx$0.7 to 1.5°C) than the airborne data and do not exhibit either a significant increase or decrease in values obtained between Stations 1 and 5.

Figure 4-20 is a line scanner printout of sea surface temperature data obtained on 5 April. Only the nadir scan position temperature values are printed (subsequent to the 8 March flights, the 45° left/right values were deemed unnecessary and were eliminated from the printout). As mentioned above, the PRT-5 infrared radiometer was not available during these flights. The following compares line scanner and sea surface truth temperatures obtained from Stations 1 and 5 along the flight line.

	Station 1	Station 5
Line Scanner (Figure 4-20)	13.4°C	13.2°C
UCSB Surface Truth (Figure 4-17)	13.0°C	12.8°C

On this day fairly good agreement (temperature difference = 0.4°C) was achieved between sea surface truth and line scanner temperature data obtained from Stations 1 and 5. However, as on 8 March, directly correlatable increasing and/or decreasing temperature data trends do not exist between the line scanner and sea surface data obtained between Stations 1 and 5.

During both the 8 March and 5 April 1977 ART flight tests comparatively small sea surface temperature anomalies existed along

TIME	LAT.	LONG.	HEADING	ALT.	SURFACE TEMP °C	
12:10:16	34:24.3 N	119:47.6 W	275.0	800	13.4	START RUN (STATION 1)
12:10:17	34:24.4 N	119:47.6 W	275.6	800	13.3	
12:10:18	34:24.4 N	119:47.7 W	276.0	800	13.2	
12:10:19	34:24.4 N	119:47.7 W	276.0	800	13.2	
12:10:20	34:24.4 N	119:47.7 W	275.7	800	13.2	
12:10:21	34:24.4 N	119:47.8 W	275.3	800	13.2	
12:10:22	34:24.4 N	119:47.9 W	275.0	800	13.2	
12:10:23	34:24.4 N	119:47.9 W	275.1	800	13.1	
12:10:24	34:24.4 N	119:48.0 W	275.4	800	13.0	
12:10:25	34:24.3 N	119:48.2 W	275.8	800	13.1	
12:10:26	34:24.3 N	119:48.2 W	276.1	800	13.2	
12:10:27	34:24.4 N	119:48.2 W	276.2	800	13.3	
12:10:28	34:24.4 N	119:48.3 W	276.3	800	13.2	
12:10:29	34:24.4 N	119:48.4 W	276.4	800	13.3	
12:10:30	34:24.4 N	119:48.4 W	276.5	800	13.2	
12:10:31	34:24.4 N	119:48.4 W	276.6	800	13.2	
12:10:32	34:24.4 N	119:48.4 W	276.8	800	13.1	
12:10:33	34:24.4 N	119:48.6 W	276.9	800	12.9	
12:10:34	34:24.4 N	119:48.6 W	277.0	800	12.9	
12:10:35	34:24.4 N	119:48.6 W	277.1	800	12.9	
12:10:36	34:24.5 N	119:48.8 W	277.1	800	13.1	
12:10:37	34:24.5 N	119:48.9 W	277.1	800	13.1	
12:10:38	34:24.5 N	119:48.9 W	277.1	800	13.1	
12:10:39	34:24.5 N	119:49.0 W	277.0	800	12.9	
12:10:40	34:24.5 N	119:49.0 W	277.0	800	12.9	
12:10:41	34:24.5 N	119:49.0 W	276.9	800	13.0	
12:10:42	34:24.5 N	119:49.1 W	276.8	800	12.9	
12:10:43	34:24.5 N	119:49.1 W	276.8	800	12.8	
12:10:43	34:24.5 N	119:49.2 W	276.7	800	13.2	
12:10:44	34:24.5 N	119:49.2 W	276.6	800	12.9	
12:10:45	34:24.5 N	119:49.3 W	276.5	800	13.1	
12:10:46	34:24.5 N	119:49.3 W	276.5	800	13.0	
12:10:47	34:24.5 N	119:49.5 W	276.5	800	12.6	
12:10:48	34:24.5 N	119:49.5 W	276.6	800	12.8	
12:10:49	34:24.5 N	119:49.5 W	276.7	800	12.9	
12:10:50	34:24.5 N	119:49.6 W	276.9	800	12.9	
12:10:51	34:24.5 N	119:49.6 W	277.0	800	12.9	
12:10:52	34:24.6 N	119:49.7 W	277.0	800	12.8	
12:10:53	34:24.6 N	119:49.7 W	277.1	800	12.8	
12:10:54	34:24.6 N	119:49.8 W	277.1	800	13.1	
12:10:55	34:24.6 N	119:49.8 W	277.1	800	12.9	
12:10:56	34:24.6 N	119:49.8 W	277.1	800	12.9	
12:10:57	34:24.6 N	119:50.0 W	277.1	800	12.9	
12:10:58	34:24.6 N	119:50.0 W	277.0	800	13.0	
12:10:59	34:24.6 N	119:50.0 W	276.9	800	13.0	
12:11:01	34:24.6 N	119:50.3 W	276.7	800	13.1	
12:11:01	34:24.6 N	119:50.3 W	276.5	800	12.9	
12:11:02	34:24.6 N	119:50.3 W	276.4	800	12.8	
12:11:03	34:24.6 N	119:50.4 W	276.3	800	12.9	
12:11:04	34:24.6 N	119:50.4 W	276.3	800	13.5	
12:11:05	34:24.6 N	119:50.4 W	276.3	800	13.5	
12:11:06	34:24.6 N	119:50.5 W	276.2	800	13.6	
12:11:07	34:24.6 N	119:50.6 W	276.1	800	13.4	
12:11:08	34:24.6 N	119:50.6 W	276.0	800	13.3	

Figure 4-20. Line Scanner ART Printout Obtained on 5 April 1977 (Altitude = 800 feet)

12:10:51	34:24.5 N	119:49.6 W	277.0	800	12.9
12:10:52	34:24.6 N	119:49.7 W	277.0	800	12.8
12:10:53	34:24.6 N	119:49.7 W	277.1	800	12.8
12:10:54	34:24.6 N	119:49.8 W	277.1	800	13.1
12:10:55	34:24.6 N	119:49.8 W	277.1	800	12.9
12:10:56	34:24.6 N	119:49.8 W	277.1	800	12.9
12:10:57	34:24.6 N	119:50.0 W	277.1	800	12.9
12:10:58	34:24.6 N	119:50.0 W	277.0	800	13.0
12:10:59	34:24.6 N	119:50.0 W	276.9	800	13.0
12:11:01	34:24.6 N	119:50.3 W	276.7	800	13.1
12:11:01	34:24.6 N	119:50.3 W	276.5	800	12.9
12:11:02	34:24.6 N	119:50.3 W	276.4	800	12.8
12:11:03	34:24.6 N	119:50.4 W	276.3	800	12.9
12:11:04	34:24.6 N	119:50.4 W	276.3	800	13.5
12:11:05	34:24.6 N	119:50.4 W	276.3	800	13.5
12:11:06	34:24.6 N	119:50.5 W	276.2	800	13.6
12:11:07	34:24.6 N	119:50.6 W	276.1	800	13.4
12:11:08	34:24.6 N	119:50.6 W	276.0	800	13.3
12:11:09	34:24.6 N	119:50.6 W	276.0	800	13.5
12:11:10	34:24.6 N	119:50.9 W	275.9	800	13.2
12:11:11	34:24.6 N	119:50.9 W	275.8	800	13.2
12:11:12	34:24.6 N	119:50.9 W	275.8	800	13.3
12:11:13	34:24.6 N	119:50.9 W	275.7	800	13.5
12:11:14	34:24.7 N	119:51.0 W	275.6	800	13.4
12:11:15	34:24.7 N	119:51.1 W	275.5	800	13.4
12:11:16	34:24.7 N	119:51.1 W	275.4	800	13.5
12:11:17	34:24.7 N	119:51.2 W	275.3	800	13.6
12:11:18	34:24.6 N	119:51.2 W	275.2	800	13.4
12:11:19	34:24.7 N	119:51.2 W	275.1	800	13.6
12:11:20	34:24.6 N	119:51.3 W	275.0	800	13.7
12:11:21	34:24.6 N	119:51.3 W	275.0	800	13.8
12:11:22	34:24.6 N	119:51.4 W	275.1	800	14.0
12:11:23	34:24.6 N	119:51.4 W	275.1	800	13.7
12:11:24	34:24.7 N	119:51.6 W	275.2	800	13.9
12:11:25	34:24.8 N	119:51.7 W	275.3	800	13.7
12:11:26	34:24.8 N	119:51.7 W	275.4	800	13.7
12:11:27	34:24.8 N	119:51.8 W	275.4	800	13.7
12:11:28	34:24.7 N	119:51.8 W	275.4	800	13.5
12:11:29	34:24.8 N	119:51.9 W	275.4	800	13.6
12:11:30	34:24.8 N	119:51.9 W	275.4	800	13.6
12:11:31	34:24.8 N	119:52.0 W	275.3	800	13.5
12:11:32	34:24.8 N	119:52.0 W	275.3	800	13.4
12:11:33	34:24.8 N	119:52.0 W	275.2	800	13.2
12:11:34	34:24.8 N	119:52.0 W	275.2	800	13.6
12:11:35	34:24.8 N	119:52.3 W	275.1	800	13.5
12:11:36	34:24.8 N	119:52.3 W	275.0	800	13.6
12:11:37	34:24.8 N	119:52.3 W	275.0	800	13.6
12:11:38	34:24.8 N	119:52.5 W	275.0	800	13.5
12:11:39	34:24.8 N	119:52.4 W	275.0	800	13.6
12:11:40	34:24.8 N	119:52.5 W	275.0	800	13.5
12:11:41	34:24.8 N	119:52.5 W	274.9	800	13.9
12:11:42	34:24.8 N	119:52.5 W	274.9	800	13.9
12:11:43	34:24.8 N	119:52.6 W	274.8	800	13.5
12:11:44	34:24.8 N	119:52.7 W	274.8	800	13.7
12:11:45	34:24.8 N	119:52.9 W	274.8	800	13.6
12:11:46	34:24.8 N	119:52.9 W	274.8	800	13.2
12:11:47	34:24.8 N	119:52.9 W	274.9	800	13.2
12:11:48	34:24.8 N	119:53.0 W	274.9	800	13.1
12:11:49	34:24.8 N	119:53.0 W	274.9	800	13.1
12:11:50	34:24.8 N	119:53.0 W	275.0	800	13.1

12:11:30	34:24.8 N	119:51.9 W	275.4	800	13.6
12:11:31	34:24.8 N	119:52.0 W	275.3	800	13.5
12:11:32	34:24.8 N	119:52.0 W	275.3	800	13.4
12:11:33	34:24.8 N	119:52.0 W	275.2	800	13.2
12:11:34	34:24.8 N	119:52.0 W	275.2	800	13.6
12:11:35	34:24.8 N	119:52.3 W	275.1	800	13.5
12:11:36	34:24.8 N	119:52.3 W	275.0	800	13.6
12:11:37	34:24.8 N	119:52.3 W	275.0	800	13.6
12:11:38	34:24.8 N	119:52.5 W	275.0	800	13.5
12:11:39	34:24.8 N	119:52.4 W	275.0	800	13.6
12:11:40	34:24.8 N	119:52.5 W	275.0	800	13.5
12:11:41	34:24.8 N	119:52.5 W	274.9	800	13.9
12:11:42	34:24.8 N	119:52.5 W	274.9	800	13.9
12:11:43	34:24.8 N	119:52.6 W	274.8	800	13.5
12:11:44	34:24.8 N	119:52.7 W	274.8	800	13.7
12:11:45	34:24.8 N	119:52.9 W	274.8	800	13.6
12:11:46	34:24.8 N	119:52.9 W	274.8	800	13.2
12:11:47	34:24.8 N	119:52.9 W	274.9	800	13.2
12:11:48	34:24.8 N	119:53.0 W	274.9	800	13.1
12:11:49	34:24.8 N	119:53.0 W	274.9	800	13.1
12:11:50	34:24.8 N	119:53.0 W	275.0	800	13.1
12:11:51	34:24.8 N	119:53.1 W	275.0	800	12.9
12:11:52	34:24.8 N	119:53.1 W	275.0	800	13.0
12:11:53	34:24.8 N	119:53.2 W	275.1	800	13.1
12:11:54	34:24.8 N	119:53.4 W	275.1	800	12.9
12:11:55	34:24.8 N	119:53.4 W	275.2	800	12.9
12:11:56	34:24.8 N	119:53.4 W	275.4	800	13.0
12:11:57	34:24.8 N	119:53.6 W	275.5	800	13.0
12:11:58	34:24.8 N	119:53.7 W	275.5	800	13.2
12:11:59	34:24.8 N	119:53.7 W	275.4	800	13.3
12:12:01	34:24.8 N	119:53.7 W	275.2	800	13.2
12:12:01	34:24.8 N	119:53.7 W	275.1	800	13.5
12:12:02	34:24.8 N	119:53.7 W	275.0	800	13.5
12:12:03	34:24.8 N	119:53.7 W	274.8	800	13.4
12:12:04	34:24.8 N	119:53.9 W	274.6	800	13.3
12:12:05	34:24.8 N	119:53.9 W	274.5	800	13.0
12:12:06	34:24.8 N	119:54.0 W	274.5	800	13.3
12:12:07	34:24.8 N	119:54.0 W	274.5	800	13.3
12:12:08	34:24.8 N	119:54.1 W	274.6	800	13.3
12:12:09	34:24.8 N	119:54.3 W	274.7	800	13.3
12:12:10	34:24.8 N	119:54.3 W	274.8	800	13.4
12:12:11	34:24.8 N	119:54.3 W	274.8	800	13.4
12:12:12	34:24.8 N	119:54.3 W	274.8	800	13.6
12:12:13	34:24.8 N	119:54.4 W	274.8	800	13.5
12:12:14	34:25.0 N	119:54.5 W	274.7	800	13.7
12:12:15	34:25.0 N	119:54.5 W	274.8	800	13.5
12:12:16	34:25.0 N	119:54.6 W	274.8	800	13.7
12:12:17	34:25.0 N	119:54.6 W	274.9	800	13.7
12:12:18	34:25.0 N	119:54.7 W	275.0	800	13.6
12:12:19	34:25.0 N	119:54.7 W	274.9	800	13.3
12:12:20	34:25.0 N	119:54.8 W	274.8	800	13.6
12:12:21	34:24.8 N	119:55.0 W	274.8	800	13.2
12:12:22	34:24.8 N	119:55.0 W	274.9	800	13.2
12:12:23	34:24.8 N	119:55.0 W	274.8	800	13.2 — END RUN (STATION 1)

3

the flight lines (a maximum of 1.3°C on 8 March and a maximum of 1.4°C on 5 April). The 8 March data shows good agreement between data obtained from the two airborne sensors, but not between the airborne sensor data and the sea surface truth data. The 5 April data shows reasonable correlation between the line scanner and sea surface truth data obtained from Stations 1 and 5, however on both 8 March and 5 April good correlation is not exhibited between line scanner and sea surface truth data trends obtained between Stations 1 and 5. Although small, differences between airborne remote temperature and sea surface truth temperature values existed throughout the performance of the ART flight tests. Possible reasons for these differences are as follows:

- Both the line scanner and PRT-5 sense temperatures that exist directly on top of the water surface. Sea surface truth temperatures were obtained with calibrated centigrade recording thermometers emersed into the water column.

- Infrared signals detected by both the line scanner and PRT-5 are increasingly attenuated by the atmosphere when going from clear to overcast conditions. Also, for any given atmospheric condition, increasing signal attenuation will occur as a function of increasing aircraft altitude. This is probably why fairly good agreement existed between the line scanner and sea surface truth temperatures obtained on 5 April (altitude = 800 feet), but did not exist on 8 March (altitude = 2400 feet) for sampling Stations 1 and 5.

- It is extremely difficult to position an aircraft over a surface truth, point sampling station that is not marked. Sampling stations 1 and 5 were marked and therefore were used for data comparison. All other sampling stations overflown were located between Stations 1 and 5, and were separated by one-half mile and/or mile intervals. These stations were not marked and could easily have been outside the temperature sensing field of view of the airborne sensors during the ART overflights. This could explain the lack of correlation existing between the airborne sensor and sea surface truth temperature data trends obtained between Stations 1 and 5 on both 8 March and 5 April 1977.

In summary, the ART modification to the line scanner performed well during the flight test program. Excellent agreement existed between the line scanner and the PRT-5 radiometric sea surface temperatures obtained. Both the line scanner and the PRT-5 sensors are capable of performing the Coast Guard's ART mission, with the line scanner offering the added advantage of providing a printout of not only temperature, but also corresponding time, aircraft position, aircraft heading, and aircraft altitude.

4.4.3.2 Simultaneous UV/IR Hard Copy Recording Modification

In order to provide a simultaneous IR/UV line scanner hard copy documentation capability, a Honeywell dry silver film recorder was incorporated into the AOSS II system. Figure 4-21 shows IR (λ = 8-13 μm) and UV (λ = 0.32-0.38 μm) images of Catalina Island which were recorded simultaneously by the Texas Instruments and Honeywell film recorders, respectively, on 29 March 1977. The annotation contained on the edge of each of the recordings contains identical mission numbers and times, thus verifying the simultaneity of the two. Figures 4-22 and 4-23 show how to interpret the annotation of each recorder.

It is noted, that at no time during the flight test program was the Honeywell recorder able to process dry silver film (dry silver paper was used to obtain all imagery). Since film is inherently easier to work with when reproducing imagery, plus the fact that the Honeywell recorder is cumbersome to operate (manual platen heater intensity adjustments are required when changing V/H ratios), the writers recommend that other dry silver recorders be investigated for use should this capability be required in future systems.

4.4.3.3 Conclusions

a. The line scanner ART modification satisfactorily provided sea surface temperature printouts as a function of time, position, heading and altitude

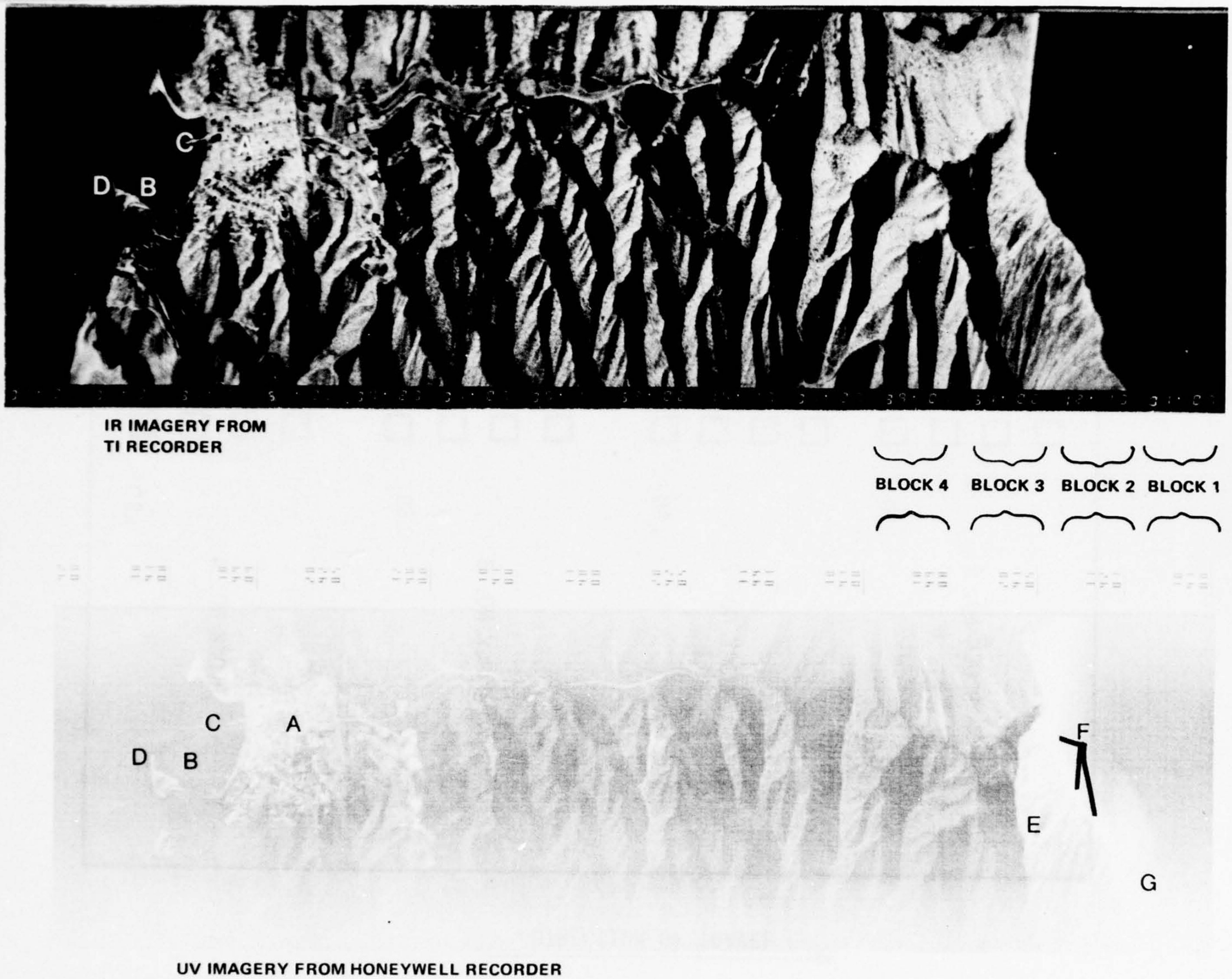


Figure 4-21. Simultaneous IR (λ = 9-13 m) and UV (λ = .32 - .38 μm) Obtained while Overflying Catalina Island on 29 March 1977. (A) Town of Avalon; (B) Avalon Yacht Harbor; (C) Steamer Pier; (D) Breakwater; (E) Bare Sandy Soi; (F) Beach Sand; (G) Suspended Sediments.

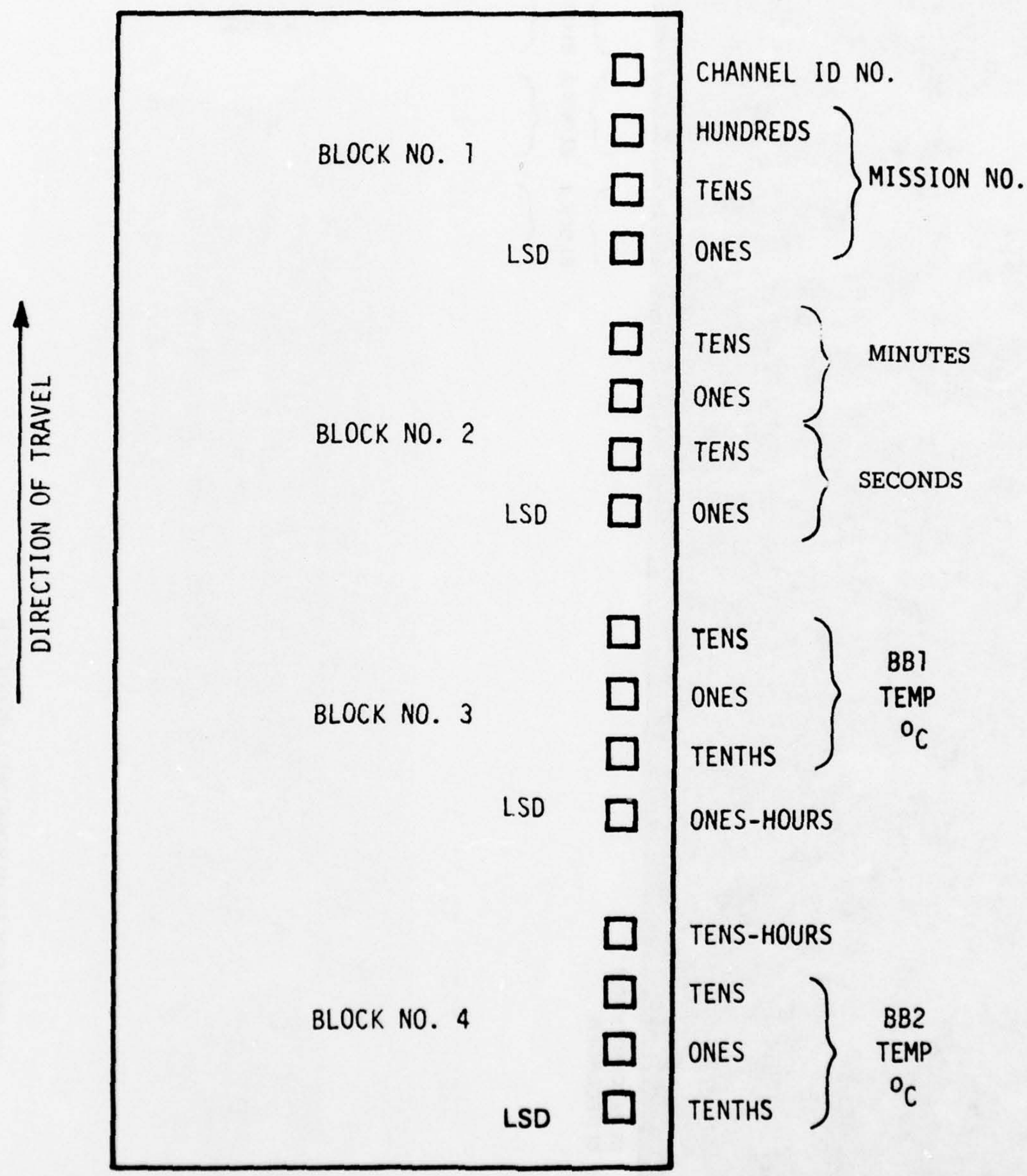


Figure 4-22. Annotation Format for Texas Instruments Recorder

a_1	b
e	c
a_2	d

BLOCK 1

d : ONES
c : TENS
b : HUNDREDS
} MISSION NO.

*a_1 & a_2 : CHANNEL ID NO. RECORDED ON TI
**e : CHANNEL ID NO. RECORDED ON HONEYWELL

a_1	b
e	c
a_2	d

BLOCK 2

a_1 : TENS
b : ONES
} MINUTES

c : TENS
d : ONES
} SECONDS

**e : CHANNEL ID NO. RECORDED ON HONEYWELL

a_1	b
e	c
a_2	d

BLOCK 3

d : ONES-HOURS

a_1 : TENS
b : ONES
c : TENTHS
} BB1 TEMP ^oC

**e : CHANNEL ID NO. RECORDED ON HONEYWELL

a_1	b
e	c
a_2	d

BLOCK 4

b : TENS
c : ONES
d : TENTHS
} BB2 TEMP ^oC

a_1 : TENS-HOURS
**e : CHANNEL ID NO. RECORDED ON HONEYWELL

* a_1 & a_2 IN THIS BLOCK ARE A TWO DIGIT CODE FOR THE CHANNEL ID# RECORDED ON THE T1 RECORDER AS SHOWN BELOW.

a_1	a_2	CH NO.
7	0	CH 1
0	1	CH 2
1	1	CH 3

**
1 = CH 1
2 = CH 2
4 = CH 3

Figure 4-23. Annotation Format for Honeywell Recorder

during the flight test program, and hence, provides a readily available capability for the performance of Coast Guard Airborne Remote Temperature missions.

b. The Honeywell recorder satisfactorily provides a dual-channel line scanner hard copy documentation capability when dry silver paper is used as the recording media. However, due to cumbersome operation, plus an inability to process dry silver film, other dry silver recorders should be investigated for use if this capability is desired in future systems.

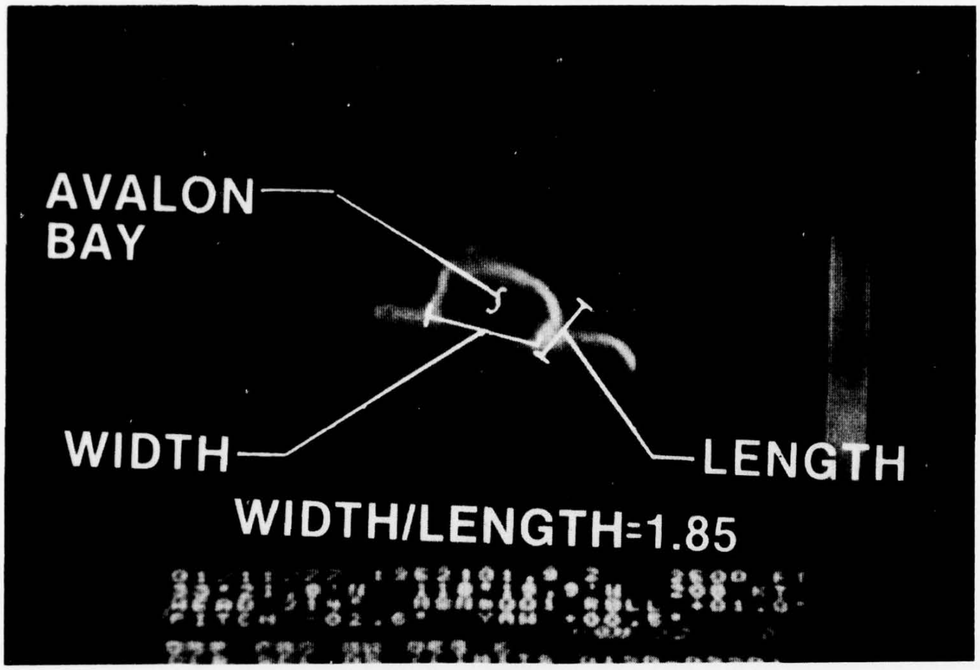
4.4.4 PMI Modification Evaluation

Passive Microwave Imager (PMI) modifications evaluated during the flight tests were (1) increased maximum scan speed (from 35 to 88 rpm) and (2) incorporation of data smoothing in the along-track and cross-track dimensions and the presentation of a traveling color scale bar chart directly adjacent to the PMI data being displayed.

4.4.4.1 Increased Scan Speed

Increasing the PMI maximum scan speed from 35 to 88 rpm necessitated two basic data format changes. The first format change is a reduction of the displayed image to one-half its previous (AOSS I) width. This was necessary due to the inability of the TV system to accept lines fast enough to maintain proper geometric aspect ratios when utilizing the AOSS I image width at a 88 rpm scan rate. The second format change was the necessity to multiplex the PMI data onto the PCM encoded tape recording due to an audio track bandwidth limitation of the video tape.

The change in size of the displayed image made it necessary to verify the geometric integrity of the PMI data by overflying targets of known geometric shape. Figure 4-24 shows two consecutive PMI images obtained while overflying Avalon Bay, Catalina Island on 11 January 1977. Figure 4-25 shows a map of Avalon Bay obtained from the Automobile Club of Southern California. Width/length aspect



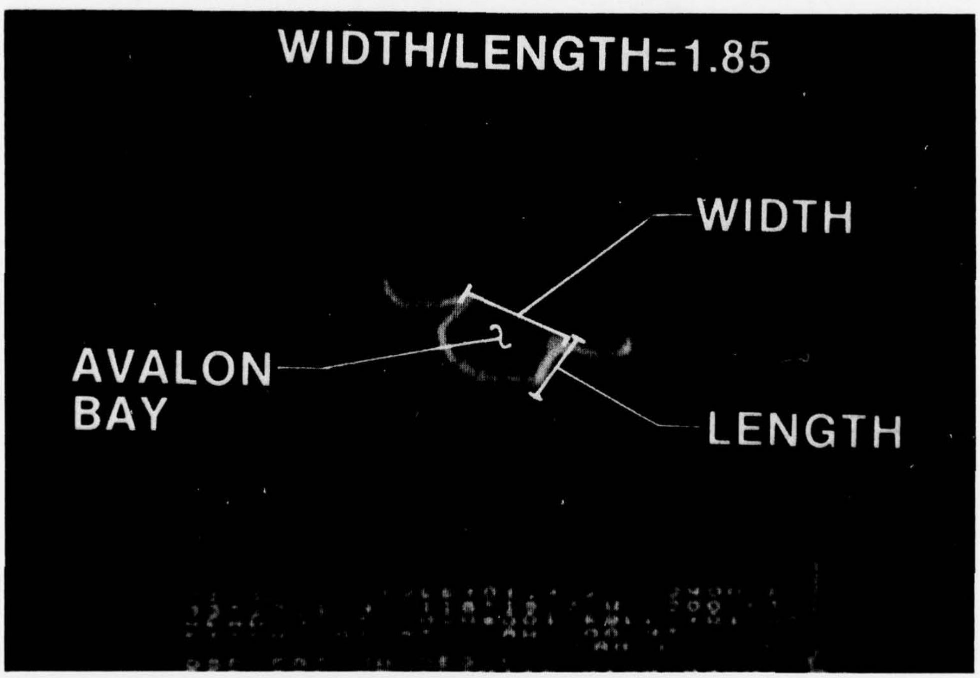


Figure 4-24. Sequential PMI Imagery Showing Calculated Width/ Length Aspect Ratios of Avalon Bay, Catalina Island

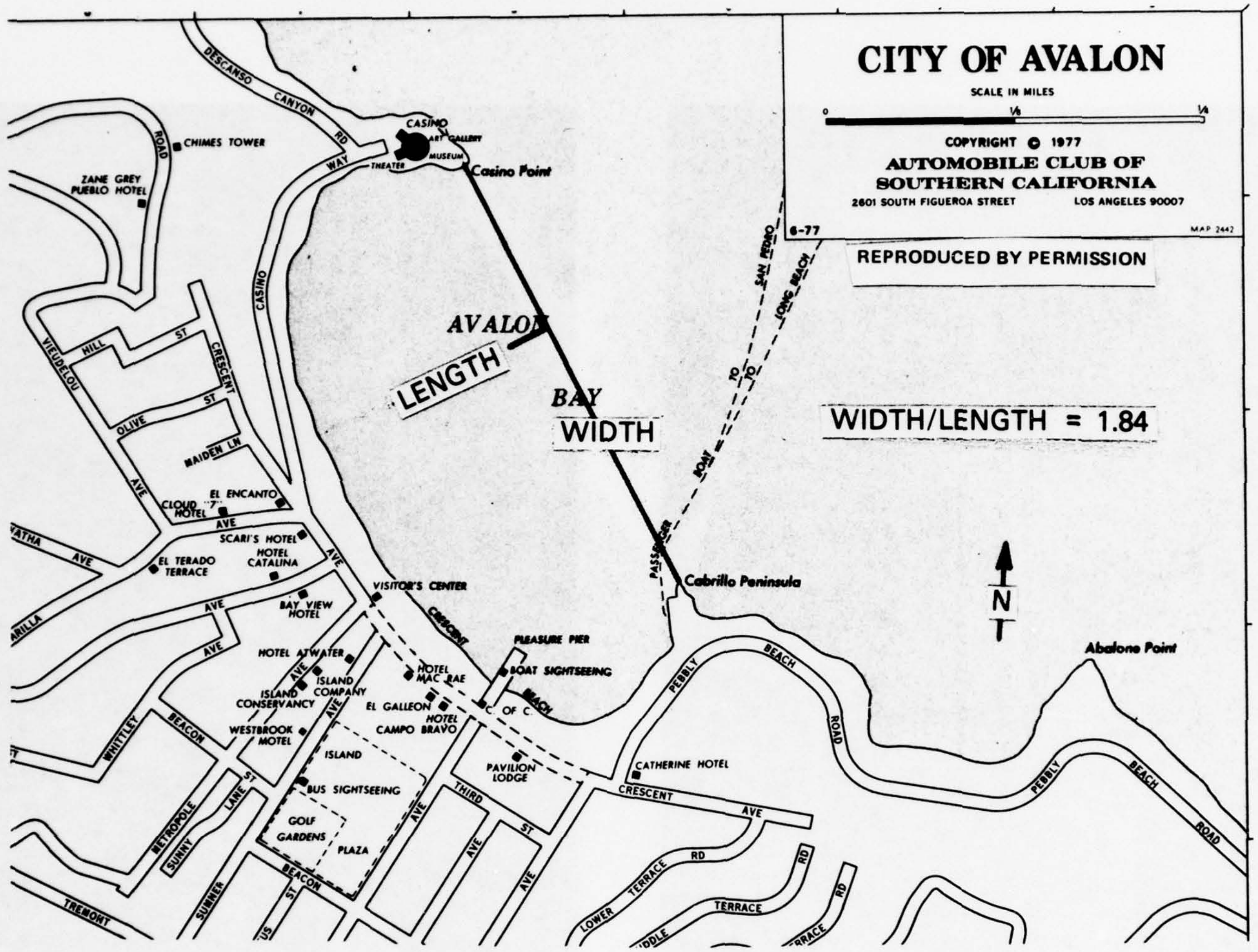


Figure 4-25. Map of Avalon Bay, Catalina Island with a Calculated Width/Length Aspect Ratio

ratios of Avalon Bay were calculated both from the PMI imagery and the map and are compared below.

	Width	Length	Aspect Ratio (Width/Length)
PMI (both images)	1.20	0.65	1.85
Map	7.00	3.80	1.84

Excellent agreement exists between the imagery and map (the width/length aspect ratio of the imagery differs by only 0.54 percent from the map). However, it is noted that these images were obtained at near optimum PMI V/H ratios (V/H = 0.1 - 0.08), and as V/H decreases in value it is not possible to maintain precise geometric accuracies. PMI scan speed is controlled by a 7-bit digital speed control word through its entire range of speeds (8 to 88 rpm) and therefore, due to the resolution of the speed control system, can exhibit aspect ratio errors of as much as ± 5 percent when low V/H ratios are encountered (i.e., ground speed = 200 knots, altitude = 10,000 feet, V/H = 0.02).

4.4.4.2 Along-Track/Cross-Track Smoothing

Along-track/cross-track smoothing was incorporated into the PMI system to produce low-noise imagery and hence, enhance the system's oil spill detection capability. Somewhat different smoothing techniques are used depending on whether the data is being displayed in real time or if the PCM encoded data is being played back. In the real-time display mode along-track, but no cross-track data smoothing is performed by the software. Cross-track smoothing is accomplished by the hardware making software processing unnecessary. Along-track smoothing is performed by interpolating data between each sequential PMI scan. Interpolated values are then applied to five out of the six TV lines that are displayed for each scan. When PCM encoded data is being played back, a cross-track interpolation is required due to the narrow bandwidth of the tape recorder which necessitates averaging every five input data elements. During this mode of

operation, the original number of display elements are recreated by cross-track interpolation between adjacent averaged elements and then applying the same along-track processing that is used for the real-time display mode.

A PMI image obtained while overflying oil during the 1974 AOSS I flight tests(described by Edgerton, et al, 1975) is shown in Figure 4-26. During this overflight surface winds were 18 knots and waves were 3 feet. As seen, oil has clearly been detected*. The brightness temperature of the sea was approximately 143^{o} to $146^{o}K$ with the oil being detected as a cool anomaly of more than $6^{o}K$. Note the "blocky" pattern of the imagery resulting in a poorly defined oil spill border.

Figures 4-27 and 4-28 are images of an oil slick resulting from Coal Oil Point oil seeps obtained during the AOSS II flight tests on 21 February 1977. During this overflight, surface winds ranged between 17 and 31 knots and seas were 4 to 6 feet high. The brightness temperature of the oil-free sea (green color) was approximately $153^{o}K$ as opposed to the oil covered sea (blue color) which exhibits a brightness temperature of approximately $149^{o}K$. As in Figure 4-26, oil has clearly been detected, however the "blockiness" of the imagery is absent and the border of the oil slick is sharply defined. Figure 4-29 again provides imagery of an oil slick resulting from the Coal Oil Point oil seeps, but on 3 March 1977 when two foot seas and 10-knot surface winds were occurring. Brightness temperatures are approximately $8^{o}K$ cooler than those obtained on 21 February. Again, note the absence of "blockiness" along with the clearly defined oil slick border exhibited by this image.

When comparing Figures 4-27 through 4-29 with Figure 4-26, the improvement in image quality due to the incorporation of along-track/cross-track PMI data smoothing into AOSS II is conspicuous. Image "blockiness" has been eliminated and low contrast targets

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*PMI oil detection concepts are given by Edgerton, et al, 1975.

PASSIVE MICROWAVE IMAGE OF A 200 GALLON SPILL (WIND 18 KT, 3 FT SEAS)

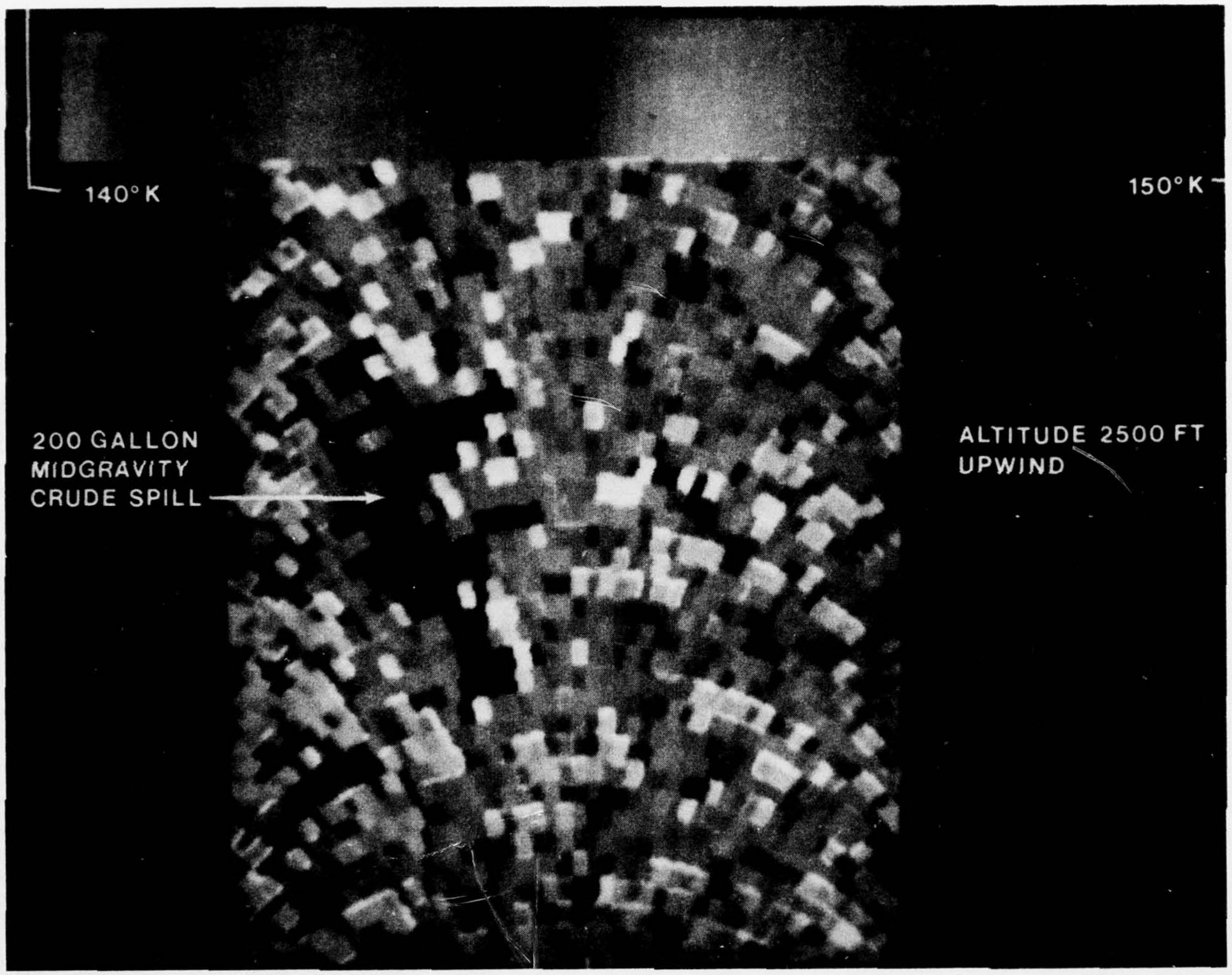


Figure 4-26. AOSS I PMI Imagery Showing Oil

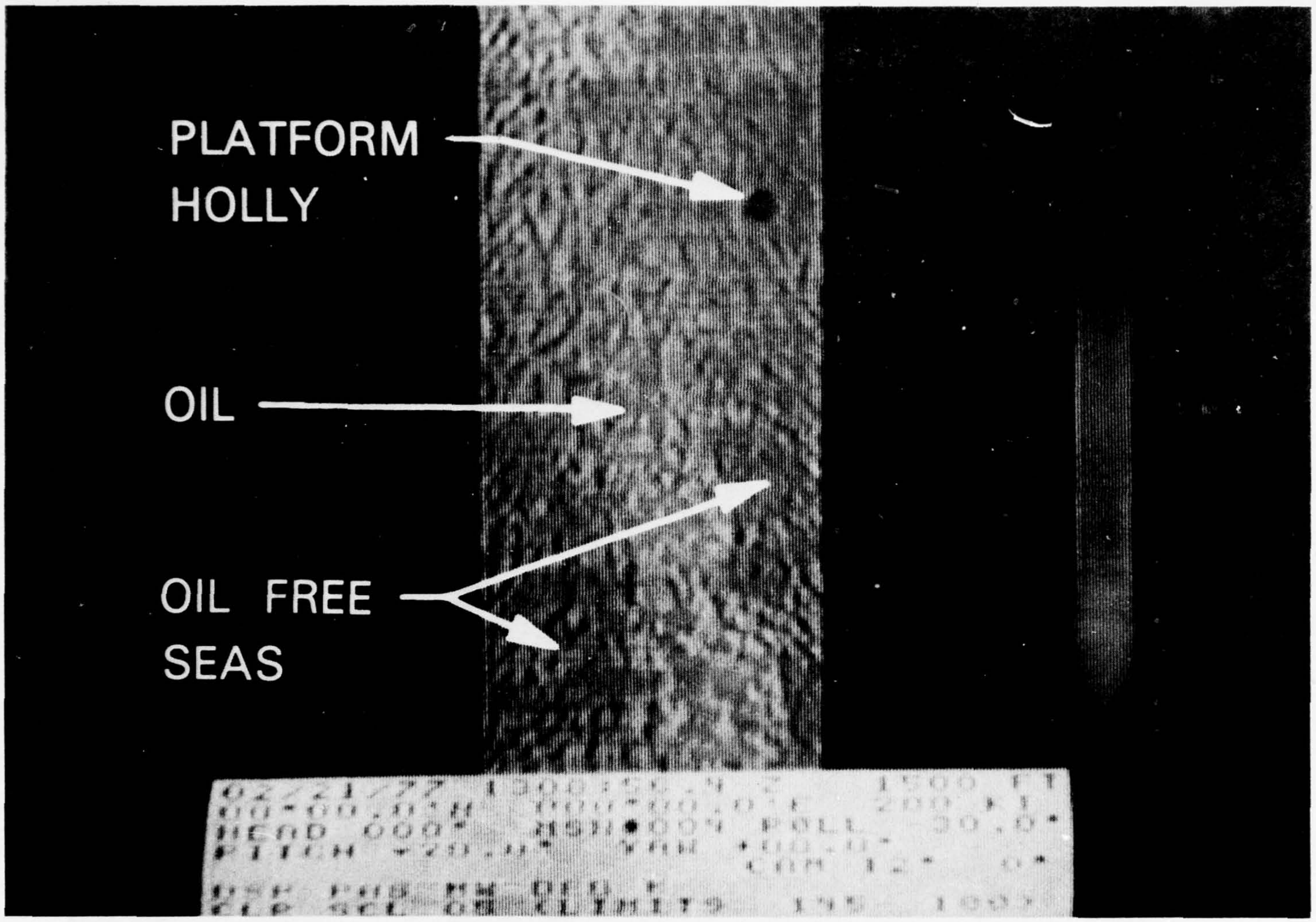


Figure 4-27. AOSS II PMI Imagery Obtained on 21 February 1977 Showing Oil

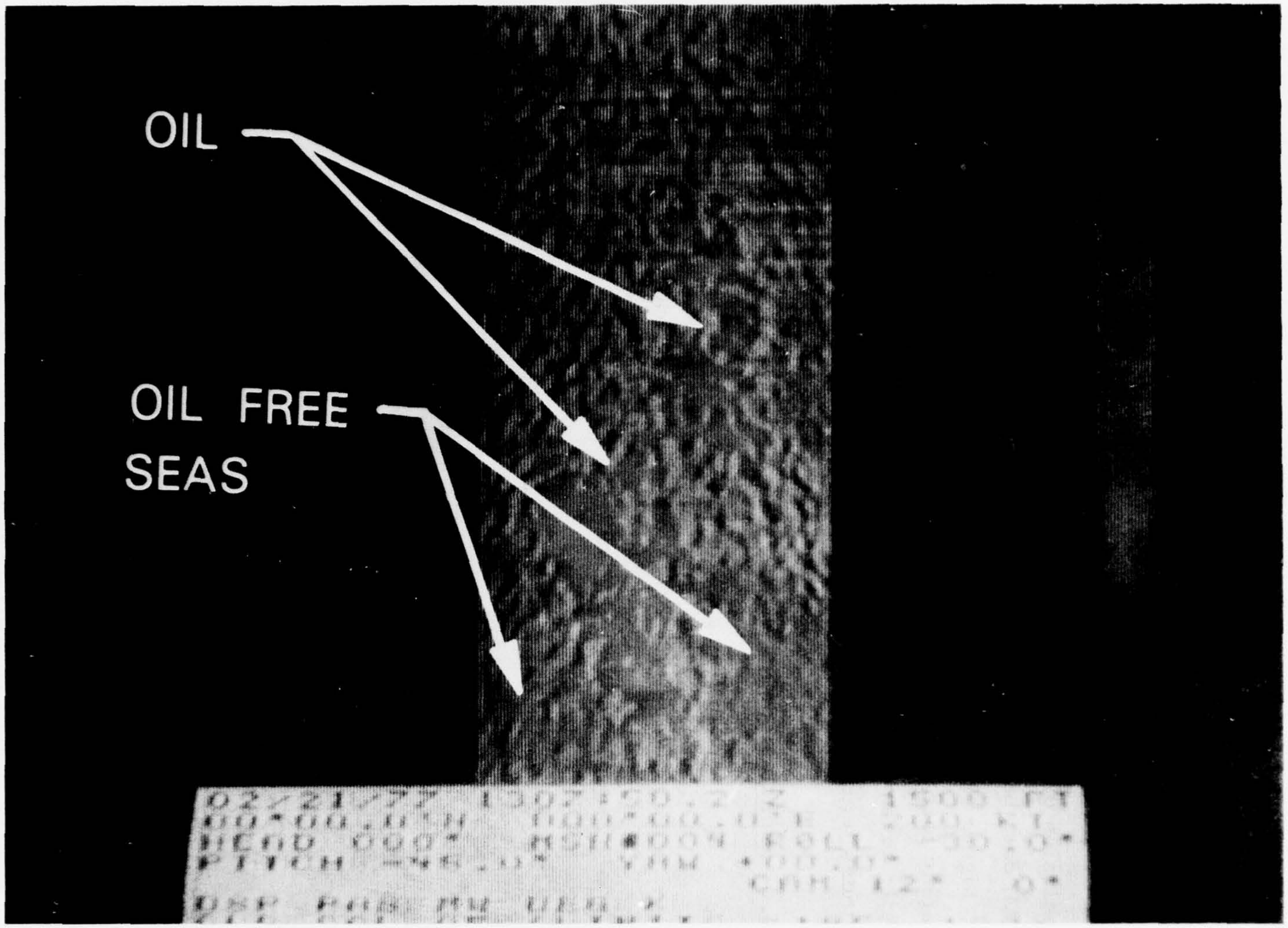


Figure 4-28. AOSS II PMI Imagery Obtained on 21 February 1977 Showing Oil

are easily detectable (the PMI consistently detected anomalies of 2-4°K throughout the performance of the AOSS II flight tests). Imagery displayed is more natural and hence, provides a more readily interpretable data product.

An additional software refinement made to the system was the inclusion of a traveling color scale bar chart directly adjacent to the PMI data being displayed (see Figures 4-27 through 4-29). Lower limit, higher limit and mid-point brightness temperatures are displayed in graphic form alongside the color scale to allow the AOSS II operator to easily set up PMI temperature limits and to facilitate real-time brightness temperature determinations.

4.4.4.3 Conclusions

a. When flying at or near otpimum V/H ratios (V/H = 0.1) the PMI imagery maintains excellent geometric integrity. However, as the V/H ratio decreases in value, aspect ratio errors increase in value and can be as high as ±5 percent when approaching a V/H ≤ 0.02.

b. The addition of along-track/cross-track data smoothing has greatly improved the quality of the PMI imagery. Low contrast targets are easily detected. The imagery exhibits a more natural appearance, and when combined with the addition of the traveling color scale bar chart, provides a readily interpretable data product.

4.4.5 KS-72 Aerial Reconnaissance Camera

The primary purpose of KS-72 aerial reconnaissance camera (ARC) data collection was to substantiate proper camera performance as a function of aircraft velocity/height, control panel settings and film type. The second objective was to document the value of the ARC for vessel identification.

The KS-72 camera system was designed and built by Hycon for military day/night reconnaissance. It is a framing-type camera

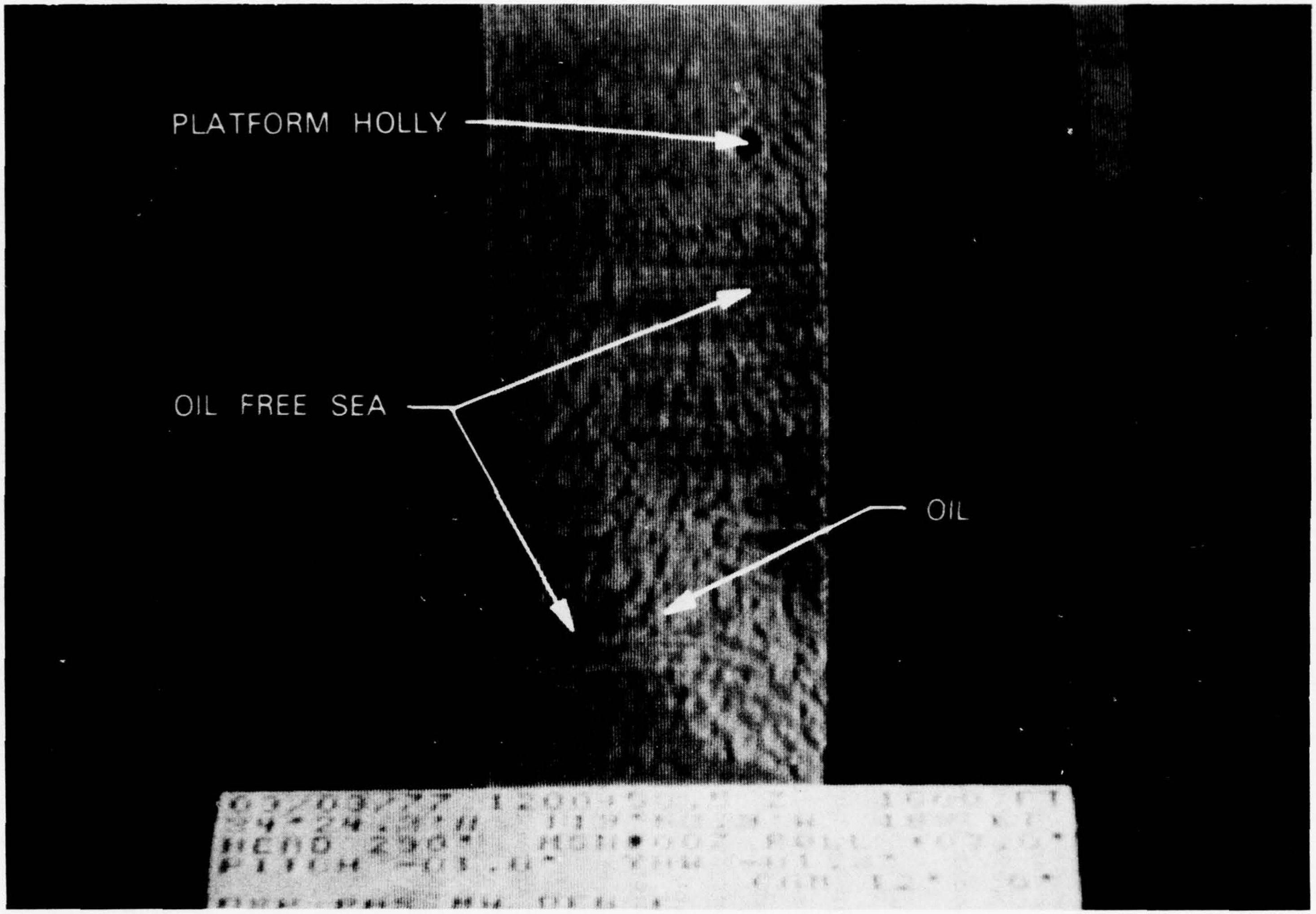


Figure 4-29. AOSS II PMI Imagery Obtained on 3 March 1977 Showing Oil

system with a cycling time of 0. 17 second which is pulse operated. During this flight test program the system was operated using 3-, 6-, and 12-inch focal length lenses. The system employs an intralens focal plane shutter with shutter speed from 1/25 to 1/100 of a second for the lenses used to acquire a 4. 5x4. 5 inch format image. The system has image motion compensation, and automatic exposure control. Film magazines can be changed in flight. During this test flight program two film types were evaluated: Kodak Ektachrome MS Aerographic Film #2448 and Kodak Plus-X Aerographic Film #2402.

Aerographic #2448 is a fine grain, medium-speed, camera color reversal aerial film. This film has excellent color rendition, good image quality, and is specifically designed for processing to a reversal (positive transparency). The 4-ML Estar Base provides good flexibility, good dimensional stability, and very high resistance to tear. Number 2448 has an abrasion resistant emulsion, an antihilation undercoat and a fast-drying backing. The thick hardened emulsion provides sharpness and permits high temperature, rapid processing in roller transport processors. The aerial film speed in daylight (no filter) was based on development in Kodak process EA-4. Resolving power noted by Eastman Kodak is:

- Test-object contrast 100:1 - 80 lines/mm
- Test-object contrast 1. 6:1 - 40 lines/mm

The Kodak Plus-X Aerographic Film #2402 is a black and white, medium-grain, panchromatic, negative film that has medium speed, medium-high contrast, and an extended red sensitivity for reduction of haze effects. The Plus-X Aerographic film's thin emulsion, coated on a 4-ML Estar Base (for flexibility), tear resistance, and dimensional stability is highly hardened for high temperature and rapid processing in a continuous processor. The aerial film speed in daylight (no filter, 200 ASA) was based on development in Kodak developed D-19 at 75°F for eight minutes in a sensitometric processing machine. Resolving power of this film is rated by Eastman Kodak as:

- Test-object contrast 1000:1 - 100 lines/mm
- Test-object contrast 1. 6:1 - 50 lines/mm

Figure 4-30 is a print of a full frame of a color image made of the bow section of a tanker named MIRALDA. Figure 4-31 is an enlargement of a section of this image depicting the vessel name quite clearly. Figure 4-32 is a print of a color image of the aft end of the same ship also showing the name. These three photographs were taken with the 6-inch lens from an altitude of 250 feet. Figures 4-33 through 4-35 are photographs of the same ship using the same lens at altitudes of 500, 1000, and 2000 feet, respectively. The vessel was documented within one frame at an altitude of 2000 feet. As seen, only the photographs obtained at an altitude of 250 feet allow reliable identification of the vessel.

Figure 4-36 illustrates the value of color photography for documenting sources of natural oil seepage. In this photo of a seep off Isla Vista, California, numerous small globules of oil and associated gas bubbles are seen surfacing in the center of the image and flowing to the right. The dull nature of the sun glint at the upper right of the photo attests to the presence of an oil film in this area of the photo.

Figure 4-37 illustrates use of the ARC for obtaining high quality data on oil thickness. Rainbow sheens are seen at A; silver sheen at B; and, light sheen at C. A knowledge of the altitude from which this photo was acquired, the focal length of the lens used to take the image, coupled with correlations of oil color and thickness would permit a general approximation of the amount of oil present in this photo.

On Figure 4-38 oil from natural seeps in the Santa Barbara Channel appears as a light silvery sheen around Platform Holly. Wavy streamers of thicker oil can be seen at the center left of the photo. This photo of Platform Holly illustrates the level of detail which can be extracted from a photograph when properly acquired. The ability to observe the triangular infrastructure of crane boom on the upper left of the platform; the similar structure of the oil derrick; and the wire mesh screening surrounding the heliport all attest to the quality of this data. On Figure 4-39 Platform Holly shows as the small, light,

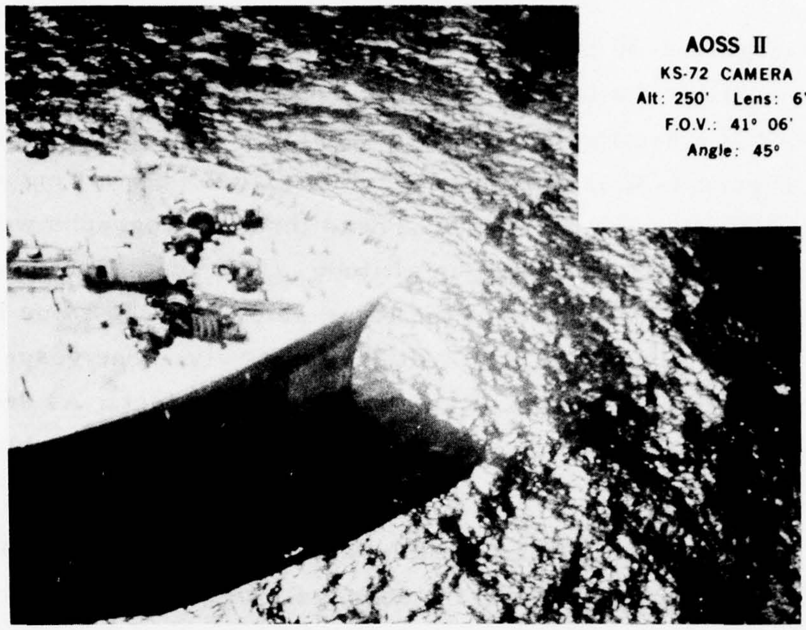


Figure 4-30. KS-72 Color Photograph Showing the Bow Section of Tanker Miralda (Altitude = 250 feet)

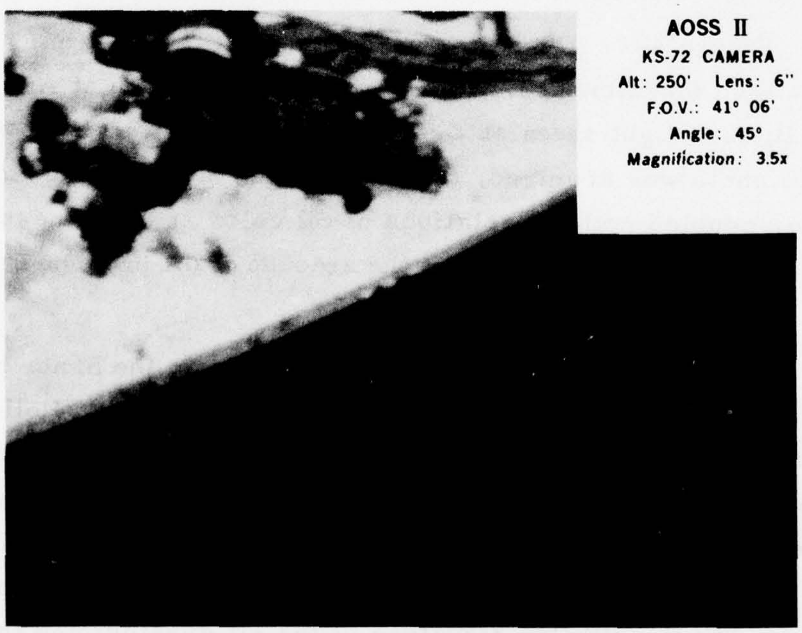


Figure 4-31. Enlarged KS-72 Color Photograph Showing the Bow Section of Tanker Miralda (Altitude = 250 feet)

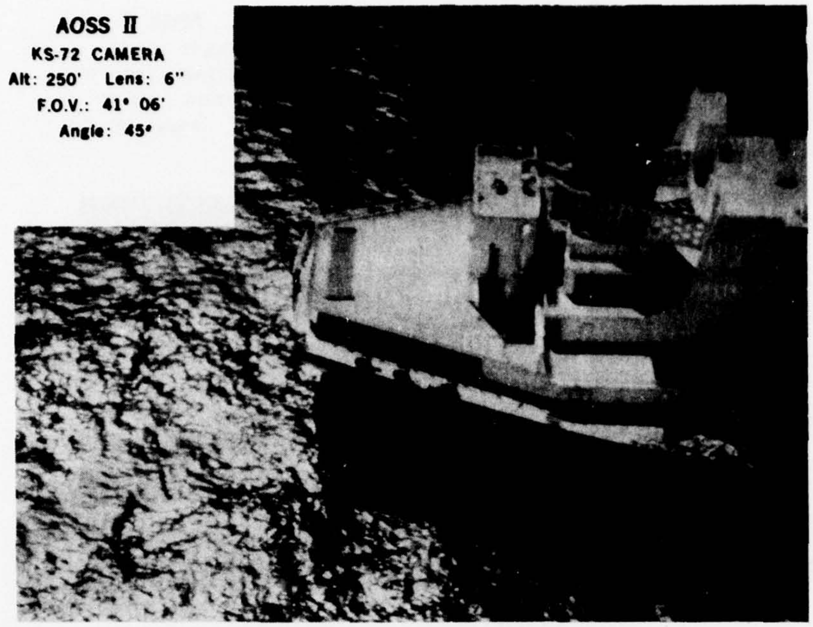


Figure 4-32. KS-72 Color Photograph Showing the Aft Section of Tanker Miralda (Altitude = 250 feet)

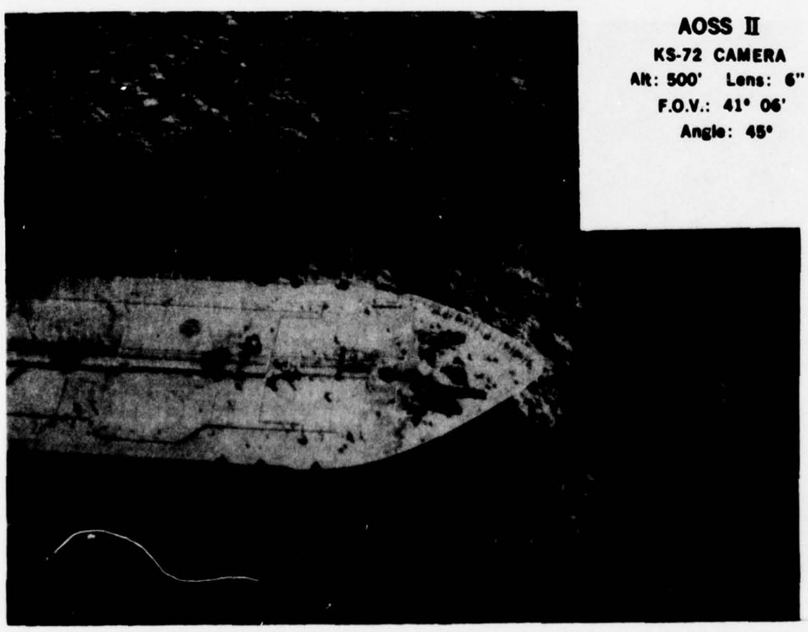


Figure 4-33. KS-72 Color Photograph Showing the Bow Section of Tanker Miralda (Altitude = 500 feet)

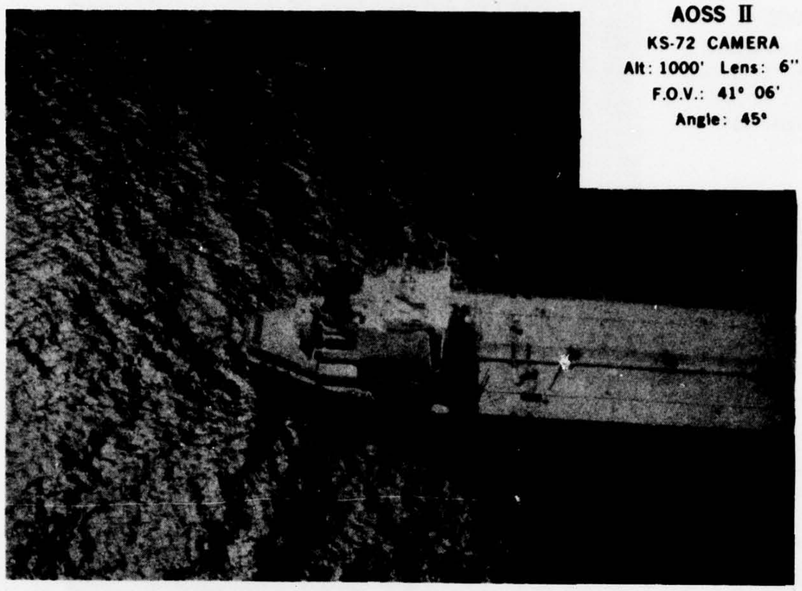


Figure 4-34. KS-72 Color Photograph Showing the Aft Section of Tanker Miralda (Altitude = 1000 feet)

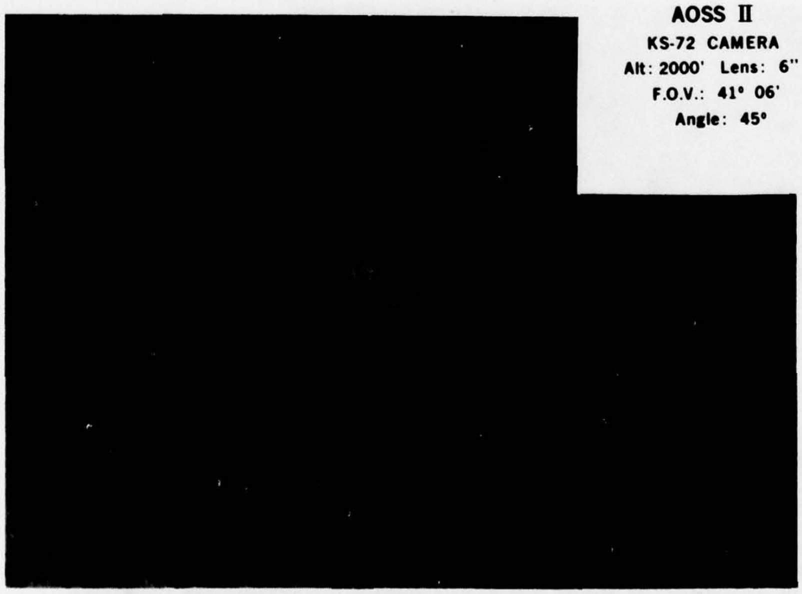
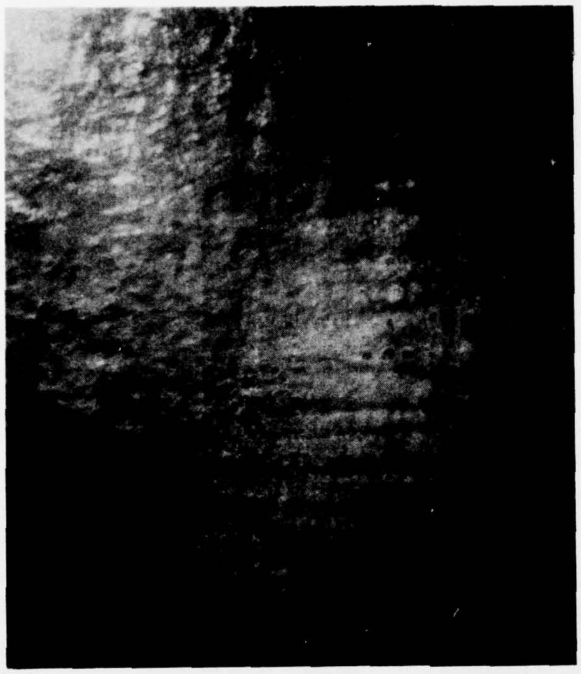


Figure 4-35. KS-72 Color Photograph Showing Tanker Miralda (Altitude = 2000 feet)



This figure illustrates the ability of color photography to document sources of natural oil seepage. In this photo of a seep origin off Isla Vista, California, numerous small globules of oil and associated gas bubbles are seen surfacing in the center of the image and flowing to the right. The dull nature of the sun glint at the upper right of the photo attests to the presence of an oil film in this area of the photo.

Figure 4-36. KS-72 Color Photograph Showing Natural Oil Seepage

This photo illustrates the ability of the KS-72A to provide high quality data on oil thickness. Rainbow sheens are seen at A; silver sheen at B; and, light sheen at C. A knowledge of the altitude from which this photo was acquired, the focal length of the lens used to take the image, coupled with correlations of oil color and thickness would permit a general approximation of the amount of oil present in this photo.

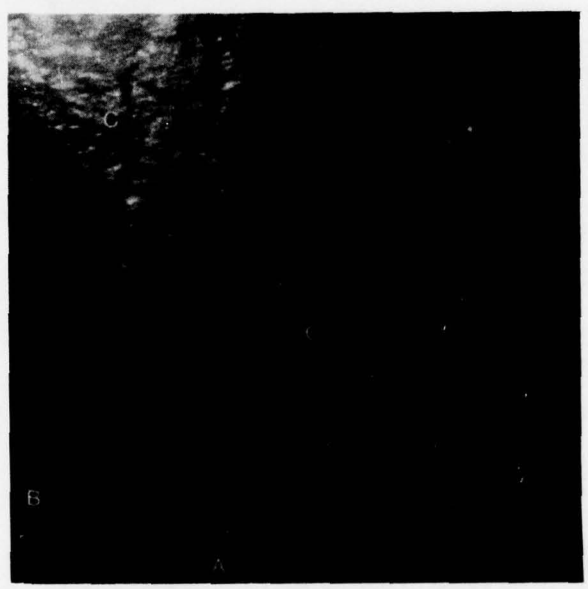
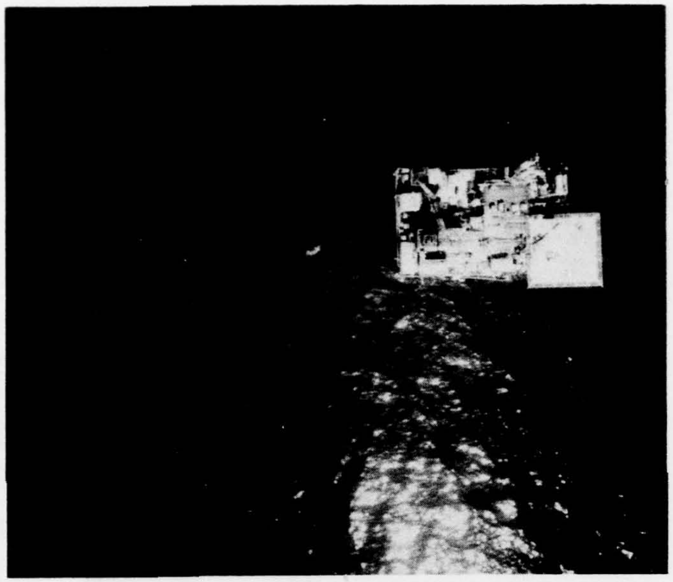
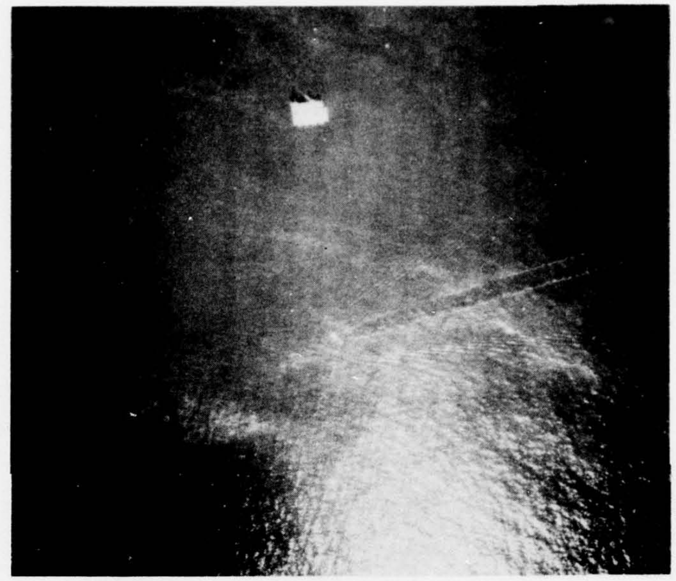


Figure 4-37. KS-72 Color Photograph Showing Different Oil Sheens



On this image oil from the natural seeps in the Santa Barbara Channel appears as a light silvery sheen around Platform Holly. Wave streamers of thicker oil can be seen at the center left of the photo. This photo of Platform Holly is an excellent example of the level of detail which can be extracted from a photograph when properly acquired. The ability to observe the triangular infrastructure of crane boom on the upper left of the platform; the similar structure of the oil derrick; and the wire mesh screening surrounding the heliport all attest to the quality of this data.

Figure 4-38. KS-72 Color Photograph Showing Platform Holly and Oil



On this photograph Platform Holly shows as the small light, rectangle in the upper center of the photo. The surface truth collection vessel is seen just below center. The wake of the surface truth vessel cuts through the surface oil accumulations from the right center to the vessel. Oil streamers ranging from light silver sheens to true silver sheens and dark gray-black streamer trending from the lower left to upper right of this photo are readily apparent.

Figure 4-39. KS-72 Color Photograph Showing Platform Holly and Oil

rectangle in the upper center of the photo. The surface truth collection vessel is in view just below center. The wake of the surface truth vessel cuts through the surface oil accumulations from the right center to the vessel. Oil streamers ranging from light silver sheens to true silver sheens and dark gray-black streamer trending from the lower left to upper right of this photo are readily apparent.

Figures 4-40 and 4-41 are examples of black and white imagery acquired with the ARC at an altitude of 1000 feet over Platform Holly (April 5, 1977). On these photographs, oil streamers (A) estimated to be 10^{-4} to 10^{-5} inches thick, image as wavy, low contrast, light gray lines. Open water around the streamers images dark gray to black, while lighter oil can be inferred from the dull nature of the sun glint pattern. Poor image quality resulting from underexposure and high sun angle reduces identification and interpretability of surface oil.

Image integrity of the ARC photography was substantiated by UCSB representatives. Annotation of ARC black and white film was demonstrated during the Southern California tests. Annotation of ARC color film required a minor modification to the airborne data annotation system which was subsequently accomplished at Elizabeth City, North Carolina, home base of the AOSS II aircraft.

Figures 4-40 and 4-41 are examples of black and white imagery acquired by KS-72 camera during overflight of Platform Holly (April 5, 1977). Film used was Kodak Plus-X Aerographic Film No. 2402. Aircraft altitude 1000 feet. On these photographs, oil streamers (A) estimated to be 10^{-4} to 10^{-5} inches thick, image as wavy, low contrast, light gray lines. Open water around the streamers images dark gray to black, while lighter oil can be inferred from the dull nature of the sun glint pattern. Poor image quality resulting from underexposure and high sun angle reduces identification and interpretability of surface oil.

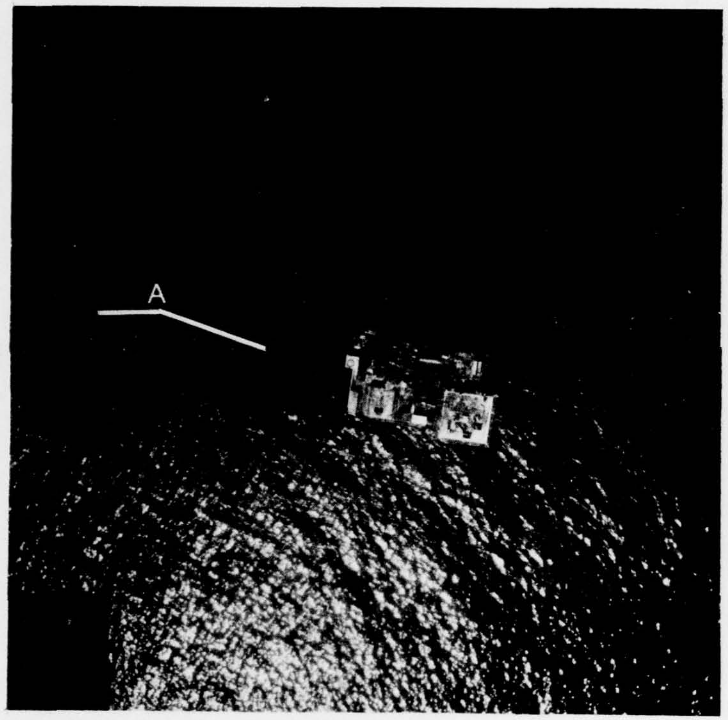


Figure 4-40. KS-72 Black and White Imagery Showing Platform Holly and Oil

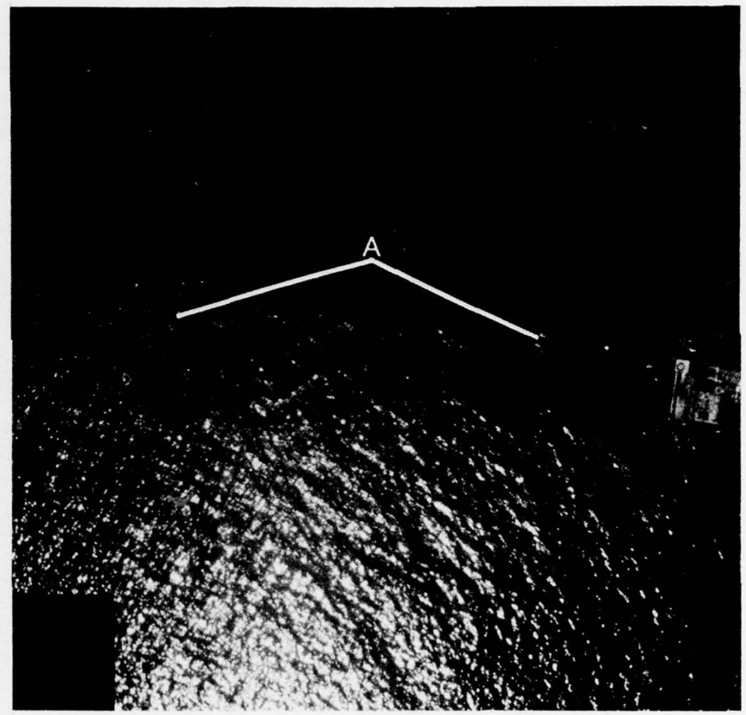


Figure 4-41. KS-72 Black and White Imagery Showing Oil

REFERENCES

Aerojet ElectroSystems Company, "Medium Range Surveillance (MRS) Aircraft Sensor System Finalization Study," Interim Letter Report A.1, Part 2, Contract No. DOT-CG-52661-A, USCG, June 1975.

Edgerton, A. T., et al, "Development of a Prototype Airborne Oil Surveillance System," Contract No. DOT-CG-22170A, USCG, May 1975.

Kraus, S. P., et al, "AOSS II Systems Verification Test," GRSC Department of Geography, Unversity of California Santa Barbara, May 1977.

Section 5

RECOMMENDATIONS

Analysis of AOSS II flight data and operational procedures augmented with extensive dialogue with system operators and users have indicated several improvements that AESC recommends be incorporated into the AOSS II system. These areas may be categorized as follows:

a. Operational improvements

b. Increased reliability

c. Improved system performance

d. Other.

5.1 OPERATIONAL IMPROVEMENTS

It is the purpose of these improvements to (1) increase system and operator efficiency, and (2) to minimize the skill level required for USCG operators thus minimizing training requirements.

5.1.1 Line Scanner Setup Aid

Proper adjustment of the line scanner gain, level and black-body temperature controls (particularly for the ART function) has proven to be time consuming. Current adjustment techniques require information from an oscilloscope and readouts from the computer control panel. Also, periodic monitoring of the associated adjustments is required to assure proper operation under changing scene and environmental conditions.

AESC recommends that a "stand alone" electronics module be incorporated into the system as an aid to setting up the line scanner. This module would indicate to the operator both the fact that a particular

adjustment was or was not optimum and the proper sense in which to adjust to a correct setting. A set of lamps for each salient control would indicate a high, normal, and low setting. Once the initial set-up was completed an occasional glance at the lamps would alert the operator to any control requiring readjustment and quickly indicate the proper sense of adjustment.

5.1.2 Capability for ART Readout - Independent of Displayed Sensor

The existing AOSS II hardware and software supports ART readout only when the line scanner data is being displayed. The ability to utilize the ART printout while displaying another sensor offers the potential of simultaneous multimission capability. For example, the SLAR could be utilized for ELT patrol or update while flying ART tracks, etc. The addition of this capability will require relatively minor modifications to the ART interface and software modifications.

5.1.3 KS-72 Pilot's Sight

Currently, no method of sighting the KS-72 aerial reconnaissance camera is incorporated into the AOSS II system. Lack of a suitable sight results in difficulty in determining the correct flight track when utilizing the 45° view angle.

Although several exotic viewfinders exist, in general they are more complex and much more expensive than required. Two cost effective techniques are (1) a window mounted reticle or (2) a small closed circuit TV camera with the image displayed on one of the console monitors.

AESC recommends the window reticle since it represents the least costly sight implementation and will provide satisfactory accuracy. Its main disadvantage is that it is somewhat less accurate than a TV sight due to viewing parallex. However, since accuracy requirements are not stringent, it is felt that a simple "two-point"

sight should provide adequate accuracy for USCG missions. The potential reticle sight locations are an observer window or the pilot's window. AESC recommends that the sight be incorporated in the pilot's window to facilitate positioning the aircraft to the proper flight track. It is also recommended that a remote camera trip switch be incorporated in the cockpit to facilitate direct exposure by the pilot. This eliminates the requirement for intercom communication between the pilot and the AOSS II operator and its associated time lag and potential for error. The reticle must incorporate subreticles to facilitate use of different camera lenses and different FOVs.

5.1.4 Expanded ADAS Altitude Readout

The current ADAS has a maximum altitude readout capability of 9999 feet. USCG personnel have indicated a desire to add an additional digit to the readout capability for higher altitude operation. The addition will require a modification to the ADAS input, output and decoding circuitry and a minor modification to the software to accommodate the additional digit. There will be no changes required to the ADAS/processor interface.

5.1.5 Read Only Memory Bootstrap

Due to operator error or hardware failure, the contents of the computer memory may be altered causing the program to be inoperative. This requires that the program be reloaded via magnetic tape. The bootstrap loader (i.e., a software routine used to input the program from the PCM track of the video recorder) is normally stored in memory. If the bootstrap instructions are not destroyed, the program may be quickly reloaded from magnetic tape. However, if the portion of memory that has been altered contains the bootstrap, the bootstrap instructions must be manually reentered using the computer control panel. Since this is a time consuming job and represents potentially significant system down time, AESC recommends that a Read Only Memory (ROM) containing the bootstrap loader be incorporated

into the CPU. Read Only Memory is not volatile as is normal computer core and this modification would eliminate the requirement for manual entry of bootstrap instructions. The CPU contains one unused slot for a Read Only Memory board.

5.1.6 Improved Cursor Control

The existing method of moving the radar target cursor consists of inputting x and y cursor coordinates via the control panel thumbwheel switches. This method was implemented on AOSS II since it represented minimum cost (i.e., only software changes were required).

Operational evaluation has shown that the use of the thumbwheel switches is slow, cumbersome and requires significant operator experience. The limitations of this implementation are particularly apparent when a large number of radar targets are present.

AESC recommends that the system be modified to incorporate a hardware-generated cursor controlled with a trackball (a trackball is an unlimited x-y input device). Since there is no space available in the fresh memory ATR box, the modification requires the addition of a small ATR box containing the cursor/trackball electronics and power supplies. Appropriate software modifications are also necessary. The trackball can be mounted on the operator's shelf.

5.2 INCREASED RELIABILITY

The purpose of these improvements is to increase reliability of the system based on historical failure analyses and operational observations.

5.2.1 Vibration Analyses and Recommendations

The AOSS II pallet is located close to the aircraft propeller line and encounters substantial vibration levels, particularly during takeoff and other high power climb conditions. AESC recommends that

a limited analysis be performed on pallet-mounted equipments. The output of this analysis would be recommended cost effective mechanical modifications to pallet mounted equipments which will minimize potential vibration induced failures.

5.2.2 Computer Refurbishment

Recently, the incidence of hard failures and unusual operating anomalies traceable to the Rolm 1602 CPU has been increasing. It is felt that the gradual deterioration is a result of a combination of total CPU operational hours, contact erosion, vibration, etc. AESC recommends a two step CPU refurbishment plan. First, the CPU cards should be replaced. The system should then be evaluated, and if further anomalies are present, the backplane and all connectors on the CPU chassis should be replaced.

5.2.3 Replacement of VTR

The VTR video tape recorder manufactured by International Video Corporation has exhibited low reliability as well as poor overall performance. It is recommended that the market be researched for a more reliable type of recorder (preferably utilizing less expensive 3/4 inch video tape) and that the new recorder be purchased and installed into the system.

5.2.4 Replacement of Current SLAR Film Processor with Dry Silver Recorder

Initiation of and maintaining the proper fluid flow of the monobath solution used to develop the SLAR film recorder has frequently proven to be difficult, resulting in occassional loss of SLAR film records. It is therefore recommended that the existing film recorder be replaced with the new dry silver version to eliminate the referenced problems of the wet processor.

5.3 SYSTEM PERFORMANCE IMPROVEMENTS

The purpose of these modifications is to enhance AOSS II system performance.

5.3.1 <u>SLAR Antenna Mounting Angle</u>

An analysis has been performed to determine the optimum mounting angle of the two SLAR antennae.* It was determined that a mounting angle of -1.5° for the 16-foot antenna and from 0 to -1° for the eight-foot antenna (measured with respect to the true horizontal) represents the optimum tradeoff between improvement in return from closer ranges and degradation of return at maximum range. It is recommended that the antennae be repositioned to these angles.

5.4 OTHER SYSTEM MODIFICATIONS

5.4.1 <u>Elimination of 28 Vdc to 400 Hz Inverters</u>

The AOSS I system (installed in a HU-16 aircraft) required 28 Vdc to 400 Hz inverters to provide 400 Hz power to portions of the system. Although 400 Hz is available on the C-130 aircraft (AOSS II), installation of the inverters were retained to minimize program costs. USCG personnel have indicated that the C-130 transformer rectifiers (28 Vdc source) are loaded down by the AOSS II equipment and have expressed a desire for load reduction by eliminating the 400 Hz inverters and directly utilizing available aircraft 400 Hz power. This modification would require rework of the power distribution panel and input power cables. It has also been suggested by USCG personnel that another AOSS II operator chair be incorporated on the pallet.

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*Letter to LCDR A. Maurer from A. T. Edgerton dated 15 July 1977.

Appendix A

UNIVERSITY OF CALIFORNIA SANTA BARBARA ACQUIRED SEA SURFACE TRUTH DATA

Meteorological/Oceanographic Data for the Santa Barbara Channel

Location: Santa Barbara Harbor

Date	Time	Wind Dir/kts	Vis. Mi.	Air Press. in Hg.	Air Temp.	Humidity %	Sea Temp.	Sea State	Surf	Small Craft Advisories WIND/SEA
11 Jan	1200	NW/02	15	30.11	50	50	57	Lt	2'	NE 20-30 kts G 50/4-6'
12 Jan	1200	N/02	15	30.11	50	50	57	Lt	2'	None
15 Feb	1200	WSW/08	15	30.10	77	35	61	Lt	2'	None
21 Feb	1200	WNW/12	6	30.05	62	82	61	Mod	4-5'	None
26 Feb	1200	N/10	25	30.35	68	44	59	Lt	1-2'	NW 15-25 kts
1 Mar	1200	NW/12	20	29.98	60	40	58	Mod-Chop	2-3'	NW 20-30 G 40 kts/5-10'
3 Mar	1200	WSW/25-30	10	29.95	62	67	57	SCA	2-4'	Gale Warning NW 20-35 kts/4-7'
8 Mar	1200	SSW/08	10	30.05	65	77	56	Lt	2'	None
29 Mar	1200	W/10	20	29.94	63	47	57	Mod-Chop	3'	NNW 15-30 kts/4-7'
30 Mar	1200	WSW/15	20	30.06	57	63	56	Lt	2'	NNW 15-25-30 kts/4-7'
4 Apr	1200	SW/15	3 F	30.19	64	66	55	Chop	1-2'	None
5 Apr	1200	WSW/13	8	30.08	63	76	55	Lt-Chop	1-2'	None
7 Apr	1200	SW/15	6	30.18	60	79	56	Lt-Chop	1-2'	None

Meteorological/Oceanographic Data for Santa Barbara Channel

Location: USCG Cutter POINT JUDITH (Mid-Channel)

Date	Time	Wind	Vis. Mi.	Sky	Air Press. in Hg.	Temperature Dry Bulb	Temperature Wet Bulb	Clouds Tenths Cover/Type	Sea Temp.	Sea Wave Dir/Hgt ft	Swell Wave Dir/Hgt ft
11 Jan	1200	220/4	15	SCT	30.04	62	60	4/10 SC	58	N/A	200/1
12 Jan	1200	220/2	10	CLR	30.01	69	65	N/A	58	220/1	220/1
15 Feb	N/A										
21 Feb	N/A										
26 Feb	N/A										
1 Mar	N/A										
3 Mar	N/A										
8 Mar	N/A										
29 Mar	1200	270/21	12	SCT	30.14	62	60	5/10 SC	54	270/5	270/16
30 Mar	N/A										
5 Apr	1200	270/7	12	SCT	30.09	56	54	3/10 AS			
7 Apr	1200	270/3	10	BKN	30.19	63	60	6/10 ST	57	270/2	270/2

Meteorological/Oceanographic Data for Santa Barbara Channel

Location: Platform HOLLY

Date	Wind Dir/kts	Vis.	Sea Temp.	Seas Height ft.
11 Jan	S/5	CLR	59	2.5
12 Jan	NW/5	CLR	59	3
15 Feb	SW/2	CLR	58	3
21 Feb	SE/5	CLDY	58	3
26 Feb	N/12	CLR	58	3
1 Mar	NW/25	CLR	58	2-4
3 Mar	NW/22	CLR	58	3
8 Mar	SW/15	CLR	58	1.5-3
29 Mar	NE/25	CLR	57	4
30 Mar	W/32	CLR	58	6
5 Apr	W/10	CLR	56	W/2
7 Apr	W/5	N/A	58	SW/2

Meteorological/Oceanographic Data for Santa Barbara Channel

Location: Santa Barbara Airport (Goleta) 1200 hr local

Date	Wind Dir/kts	Vis.	Sky/Ceiling	Air Press. in Hg.	Air Press. in Mb.	Air Temp.	Dew Point	Total Sky Cover Tenths	Total Opaq Sky Cover
11 Jan	00/00	25	E 200 BKN	30.04	180	60	44	9	6
12 Jan	140/06	20	CLR	29.98	159	61	51	0	0
15 Feb	320/05	25	CLR	30.08	193	84	42	0	0
21 Feb	260/17G31	20	6 SCT 40 SCT E 120 BKN	30.05	183	66	57	8	5
26 Feb	280/10	25	CLR	30.29	264	65	36	0	0
1 Mar	E340/15	25	CLR	30.00	166	63	19	0	0
3 Mar	E250/10	25	60 SCT 100 SCT	30.01	169	68	36	4	3
8 Mar	230/06	15	250 OVC	30.03	176	66	52	10	4
29 Mar	210/13	25	CLR	29.96	152	62	31	0	0
30 Mar	270/17G24	25	30 SCT	30.04	180	55	36	3	3
5 Apr	230/07	07	250 SCT	30.08	193	65	45	4	1
7 Apr	150/08	05FH	8 SCT	30.16	220	57	52	4	3

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